FAA-E-2732b
August 20, 1986

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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
SPECIFICATION

AUTOMATED WEATHER OBSERVING

SYSTEM

(AWOS)

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SPECIFICATION

AUTOMATED WEATHER OBSERVING SYSTEM SPECIFICATION

PART 1 - GENERAL

1-1 SCOPE

1-1.1 Purpose.- This Part establishes the description of the Automated Weather Observing System (AWOS), and the general requirements applicable to each component or subsystem, unless specifically stated otherwise in other Parts of this specification.

1-1.2 Overall System Description.- This specification contains the FAA requirements for the design, production and testing of an Automated Weather Observing System (AWOS) for aviation usage. The AWOS consists of an array of meteorological sensors, data collection packages, a processor with associated software/firmware, data distribution methods (such as computer generated speech, digital data distribution links and dial-up telephone access), and remote maintenance monitoring.

The functions of the AWOS include the measurement of weather elements, data acquisition and processing, observation dissemination (display and communications), maintenance self-monitoring and limited archiving. The AWOS shall be a flexible and modular system capable of operating at different locations throughout the National Airspace System in a variety of configurations, and operating with or without the attendance of a qualified observer. Unattended, it shall automatically collect, process, ensure the quality of, format and report the weather observation. When attended, it shall also accept inputs from a qualified observer who may add to or modify the automatically generated weather observation and/or add airport/approach/runway data through a voice recording. The AWOS must be modular so that only the site-unique capabilities (e.g., weather parameters, displays, communication facilities) need be implemented at any particular site. The system shall have the capability to interface with weather sensors in varying combinations, and with various communications systems.

The system shall be designed to operate continuously with high reliability, under varied and sometimes hostile weather conditions, without the need for human intervention. The equipment shall be optimized for simplicity, reliability, maintainability, energy efficiency, weight and ease of installation consistent with the requirements of the Federal Aviation Administration (FAA).

<u>1-2 APPLICABLE DOCUMENTS</u>.- The following specifications, standards, publications and the amendments in effect on the date of the invitation for bids or request for proposals, form a part of this specification and are applicable to the extent specified herein.

<u>1-2.1 FAA documents</u>

FAA-STD-002	Engineering Drawings
FAA-STD-005	Preparation of Specification Documents
FAA-STD-013	Quality Control Program Requirements
FAA-STD-018	Computer Software Quality Program Requirements
FAA-STD-019	Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities
FAA-STD-020	Transient Protection, Grounding, Bonding and Shielding Requirements for Equipment
FAA-STD-021	Configuration Management
FAA-STD-024	Preparation of Test and Evaluation Plans and Test Procedures

FAA-STD-025	Preparation of Interface Control Documents
FAA-STD-028	Contract Training Programs
FAA-ORD-1020.1	Transition to the Metric System
FAA-ORD-1320.33	Equipment Modification and Facility Instruction Directives
FAA-ORD-1800.8	National Airspace System Configuration Management
FAA-ORD-6000.10	Airway Facilities Service Maintenance Program
FAA-ORD-6000.15	General Maintenance Handbook for Airway Facilities
FAA-ORD-6000.26	Reliability and Maintainability Policy
FAA-ORD-6000.27	Transmittal of Maintenance Philosophy Steering Group (MPSG) Report
FAA-ORD-6000.30	Airway Facilities Service Policy Decisions for the Maintenance Program for the 1980's
FAA-ORD-6030.28	Preparation, Processing and Management of Specification, Orders and Interface Control Documents
FAA-ORD-7110.10	Flight Services Handbook
FAA-ORD-7340.1	Contractions
FAA-D-2494	Technical Instruction Book Manuscripts; Electronic, Electrical and Mechanical Equipment, Requirement for Preparation of Manuscript and Production of Books
FAA-E-2269	Runway Visual Range Specification
FAA-E-2698	Maintenance Processing Subsystem of the Remote Maintenance Monitoring System

FAA-NAS-MD-790	National Airspace System Configuration Management Document (Interface Control Document for the Remote Maintenance Monitoring System)
FAA-NAS-MD-792	Operational Requirements for the RMMS
FAA-NAS-MD-793	RMMS: Functional Requirements for the Remote Monitoring Subsystem (RMS)
FAA-AC 150/5345-1	Approved Airport Lighting Equipment
10-001	AWOS/ADAS Interface Control Document (Draft).

1-2.2 Military documents

DOD-STD-100	Engineering Drawing Practices
DOD-STD-1678	Fiber Optics Test Methods and Instrumentation
DOD-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment
DOD-STD-2167	Defense System Software Development
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)
MIL-STD-471	Maintainability Verification/Demonstration/ Evaluation
MIL-STD-721	Definitions of Terms for Reliability and Maintainability

MIL-STD-785	Reliability Program for System and Equipment Development and Production
MIL-STD-810	Environmental Test Methods
MIL-STD-1388-1	Logistics Support Analysis
MIL-STD-1388-2	DOD Requirements for a Logistic Support Analysis Record
MIL-STD-1521	Technical Reviews and Audits for Systems, Equipments and Computer Software
MIL-STD-1561	Uniform DOD Provisioning Requirements
MIL-C-81309	Corrosion Prevention Compounds, Water Displacing, Ultra-Thin Film
MIL-E-17555	Electronic and Electrical Equipment Accessories and Repair Parts: Packaging and Packing of
MIL-I-46058	Insulating Compound, Electrical (for coating printed circuit assemblies)
MIL-M-7298	Manuals Technical: Commercial Equipment
MIL-HDBK 217	Reliability Prediction of Electronic Equipment
NAVMAT P-9492	Navy Manufacturing Screening Program

1-2.3 Other documents

ACI 318	American Concrete Institute Standard Building Code Requirements for Reinforced Concrete
ASTM A615	ASTM Specification for Deformed and Plain Billet Steel Bars for Concrete Reinforcements
ANSI X3.64/X3.66	American National Standard for Advanced Data Communication Control Procedures (ADCCP)
ANSI STD Z 136.1	Accessible Emission Limits for Laser Radiation
ANSI/IEEE STD 829	IEEE Standard for Software Test Documentation
Bell Publication 43401	Transmission Specifications for Private Line Metallic Circuits
Dept. Labor Std.	Department of Labor Standard, Title 29, Chapter XVII, Part 1910

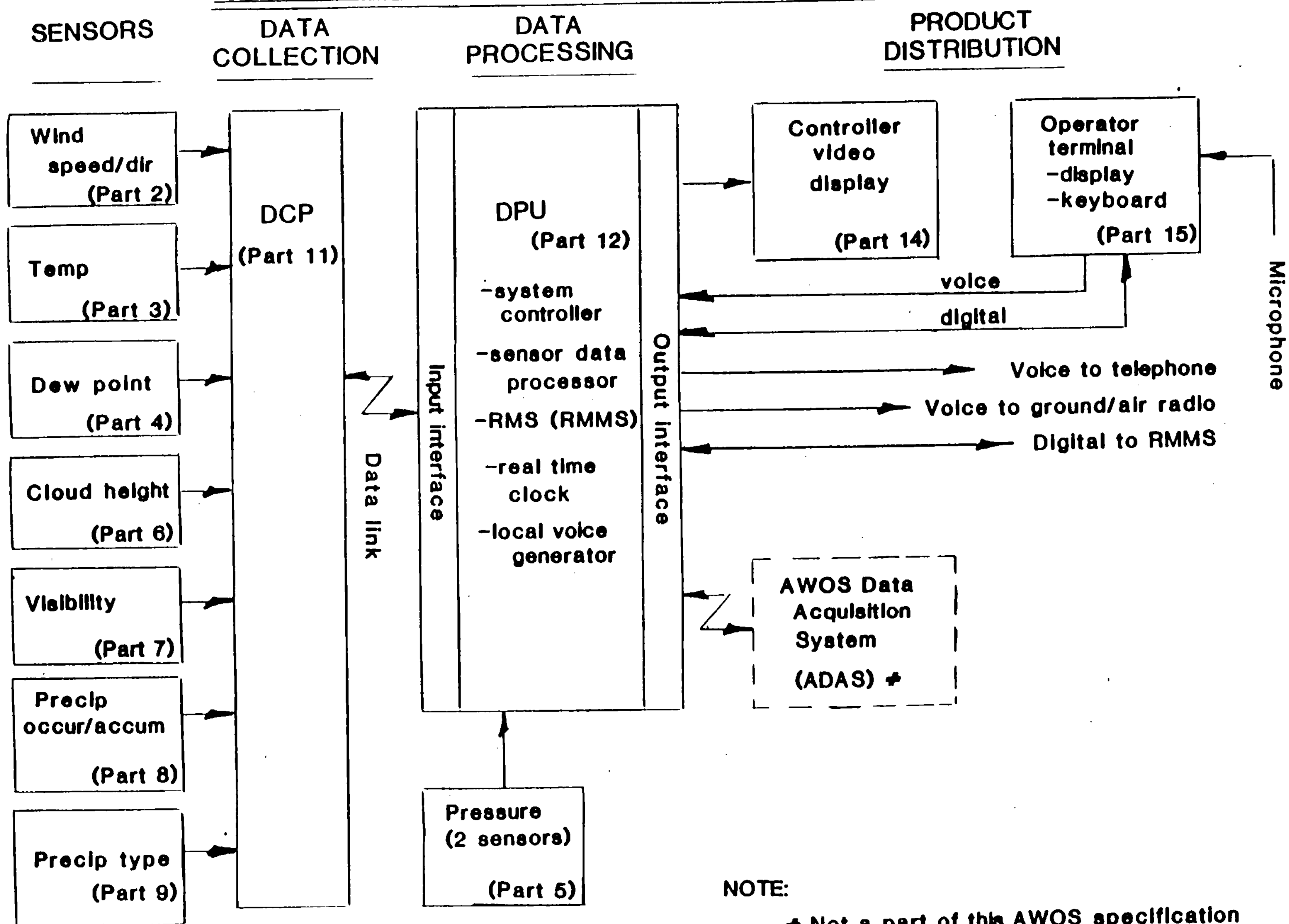
EIA-STD-RS-232C	Interface Between Data Terminal Equipment, and Data Communication Equipment Employing Serial Binary Data Interchange
EIA-STD-RS-449	Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Exchange
EIA Bulletin No. 12 -	Application Notes on Interconnection Between Interface Circuits Using RS-449 and RS-232C
FCC	Federal Communications Commission (FCC) Rules and Regulations, Part 2
FED-STD-1003	Federal Standard: Telecommunications; Synchronous Bit Oriented Data Link Control Procedures [Advanced Data Communications Control Procedures]
FMH No. 1	Federal Meteorological Handbook No. 1: Surface Observations
NFPA No. 70	National Electrical Code
NFPA NO. 78	Lightning Protection Code
NTIA	National Telecommunications and Information Administration (NTIA) Manual of Regulations and Procedures for Federal Radio Frequency Management
RTCA/DO-160	Radio Technical Commission for Aeronautics: Environmental Conditions and Test Conditions for Airborne Equipment

1-2.6 Precedence.- When conflicts exist between the requirements of the contract and this specification, the contract shall take precedence. When conflicts exist between the requirements of this specification and its referenced documents, this specification shall take precedence.

1-3 REQUIREMENTS

1-3.1 General.- The AWOS design includes meteorological sensors, data communicators, processing software and hardware and displays, an operator terminal, a voice output, and remote maintenance monitoring. An overall system block diagram is shown in Figure 1-1. This document also specifies various support items for AWOS such as: sensor test and calibration equipment, a maintenance data terminal (MDT), a software development system, a radio and fiber optics data link, and system documentation.

AUTOMATED WEATHER OBSERVING SYSTEM



NOTE:

✱ Not a part of this AWOS specification

FIGURE 1

The AWOS Data Acquisition System (ADAS) is a facility that will collect data from a number of AWOS observation sites. The ADAS will process, check and store this data, and will disseminate it to various users. The ADAS is not a part of this specification; however, the AWOS shall contain the capability to interface with the ADAS as described in this specification.

AWOS will be in service during a period when a number of other FAA programs will be developed and implemented. It is therefore necessary that the AWOS production system shall perform in the present and shall have the capability to adapt to future FAA programs.

1-3.1.1 Equipment to be furnished by the contractor.- The contractor shall provide all the necessary equipment (to include hardware and software) to perform sensing, data processing, control, data dissemination (to include display and voice), limited archiving, software development and maintenance and test functions. As specified in the contract, the contractor shall furnish all items and services required for site preparation and installation. The contractor shall also provide spare cards, modules, and parts (from a listing approved by the FAA) that may be required after operational installation.

1-3.1.2 System expandability.- The AWOS shall be capable of accepting different sensor types, and of upgrading with newer, improved sensors without requiring major hardware redesign or major software changes. Introduction of a new sensor (whose output is either analog or digital) shall be accomplished by plugging a sensor interface card into the Data Collection Package (DCP) or the Data Processing Unit (DPU), and by exchanging EPROMS in the Data Processing Unit (DPU) to change or add the new sensor processing algorithm. Some examples of new or upgraded sensors are: Obstruction to Vision Detection, Lightning (Thunderstorm) Detection, Freezing Rain Occurrence, Runway Visual Range, Low Level Wind Shear and measurement of cloud heights in excess of 5500 feet. The AWOS system shall have the capability to have the software/firmware expanded by up to 50 percent of the total lines of code initially implemented. Additionally, the system shall have the capability for a 50 percent growth in the system (additional sensors, outputs, etc.).

1-3.2 System characteristics

1-3.2.1 Performance characteristics.- The overall system characteristics for the AWOS are defined by this Part of the specification. The characteristics of individual sensors, equipment and subsystems comprising the AWOS are defined by subsequent Parts.

1-3.2.2 General system characteristics.- This specification contains the requirements for an AWOS system, and the requirements stated in each Part apply to the total system. Resolution, accuracy, time constants, and other characteristics identified for each sensor (or other component) are a requirement for the output from the system. This system output reflects the accumulation of all sources of error in the system.

Therefore, the system contractor shall design, produce (or procure from a subcontractor) and install all components (i.e., sensors, DCP, DPU, system communications, etc.) so that when integrated into a system, the system output will satisfy the requirements identified in each applicable Part of this specification.

1-3.2.2.1 Power requirements.- The AWOS equipment shall operate on commercial power sources (120 or 240 volt ± 10%, 60 Hz ±5%, single phase). All data processing, electrical and electronic components (excluding heaters, blowers, aspirators, and obstruction lights) shall be protected from power surges and transients. The system shall be equipped with input and output fuses and/or circuit breakers and semiconductor protection devices.

In the event of a loss of ac main power, the following shall occur:

(a) The AWOS will stop normal operation (i.e., the collection and distribution of weather observations shall cease).

(b) A battery backup system shall provide power to the appropriate processor circuitry to maintain the RAM for a period of four (4) hours, archive data for a period of 15 days, and to the real time clock for a period of 30 days, at an ambient air temperature of 40°F.

The AWOS shall have a "self-start" feature that will permit an automatic return to normal operation of the system (i.e., without human assistance) within 30 minutes at -40°F, and within 10 minutes at 20°F and without damage, after a loss of and reapplication of ac main power of any duration. Return to normal operation of the dewpoint sensor is addressed in part 4, paragraph 4-2.1.

The total power consumption of the AWOS system (sensors, DCP's, DPU, controller video display, observer terminal, voice subsystem) with all heaters operational shall not exceed 6 (six) kilowatts. (Convenience outlets are excluded). System design to reduce this value is encouraged.

1-3.2.2.2 Physical characteristics: standard natural environmental operating conditions.- The following requirements describe the expected operating environment of the AWOS system. Tests are described in this document that exceed these requirements in order to provide accelerated stress screening conditions.

(a) Equipment installed indoors (i.e., any acquisition and/or processing equipment installed indoors, displays, operator terminal, maintenance data terminal, micro-processor development system, the pressure sensors (if installed indoors), indoor test and calibration equipment, and the battery systems associated with these items of equipment) shall operate (and survive) under the following conditions:

(1) Ambient temperature: $+40^{\circ}$ to $+105^{\circ}$ F operating, (survive -40° to +150°F) (displays, -20° to +150°F, survive)

(2) Relative humidity: 5% to 90% operating

(3) Pressure Altitude: -1,500 to 10,000 feet pressure altitude operating, (survive -1,500 to 18,000 feet pressure altitude)

(b) Equipment installed outdoors (i.e., the sensors, including pressure sensors, (if installed outdoors), any communications, acquisition and/or processing equipment installed outdoors, and the outdoor test and calibration equipment, and battery systems associated with these items of equipment) shall operate (and survive) under the following conditions:

(1) Ambient Temperature: Operating, -60° to $+130^{\circ}$ F, (survive -40° to +150°F). (Test and calibration equipment, 0°F to 120°F operate and survive). (Sensors, -58° to +150°F, survive).

(2) Relative humidity: 5% to 100% with condensation due to temperature changes, operate and survive

(3) Wind: 100 knots, operate and survive

(4) Ice buildup: Freezing rain rate equivalent to a buildup of one-half inch per hour (over a 60-minute period) radial thickness of clear ice operating (except for wind speed and direction sensors whose accuracy is permitted to deteriorate during icing conditions) (survive up to one inch with no wind)

(5) Pressure Altitude: -1,500 to 10,000 feet pressure altitude operating, (survive -1,500 to 18,000 feet pressure altitude)

(6) Snow: Accumulation of 12 inches, at a rate of 2 inches per hour at 20° F, with winds of 40 knots from any direction, operate and survive

(7) Hail: one-half inch diameter hail, operate and survive

(8) Rain: to 3 inches per hour with 40 knot winds, operate and survive

(9) Salt Fog: MIL-STD-810, Method 509.2, Procedure I, operate and survive

(10) Solar Radiation: MIL-STD-810, Method 505.2, Procedure I, operate and survive

(11) Fungus Growth and Chemical Corrosion Protection: As a preventive measure against fungus growth and chemical corrosion, all electronics and connectors shall be coated with a material meeting MIL-C-81309 type III requirements.

(c) All equipment accepted FOB origin shall conform to the transportation and handling vibration requirements in MIL-STD-810, Method 514.3, Category I. For bench handling: MIL-STD-810, Method 516.3, Procedure VI.

(d) Additional requirements specified for specific subsystems are listed in the appropriate section.

1-3.2.2.3 Adaptation for warm climate installation.- The AWOS system shall have connection devices that will permit some of the heaters to be disconnected as required. This will allow reduced power requirements at warm climate locations.

1-3.2.2.4 Overheat protection.- Electronic circuits that might be damaged from thermal overheat shall be protected by a thermal sensor that will disconnect input power from the equipment. The RMMS shall be alerted when temperatures are in a marginal range before power disconnect. The thermal sensor shall restore the equipment to normal operation when temperatures decrease within limits.

1-3.3 Design and construction

1-3.3.1 Modularity.- The components, assemblies, and software of the AWOS system shall be separated into physically and functionally distinct modules. A module may be a subsystem (e.g., a visibility sensor or the DPU), or a circuit board or card within the subsystem. Module interfaces shall be standardized such that a module may be replaced without requiring recalibration. (This feature may require that a sensor and its personality interface be precalibrated at the factory).

Modularity concepts shall be employed to permit the AWOS to be deployed in a variety of configurations to meet unique site-specific requirements, usually by adding or substituting sensors, output devices or output circuitry. In addition, the system design must consider the situation where the sensors are collocated with the DPU.

The AWOS shall provide for future expansion capabilities through the use of modular design techniques.

Modular design techniques shall be used to facilitate fault isolation, as well as faulty-component removal and replacement, thus reducing maintenance costs by lowering required maintenance skill levels, training, and parts inventories.

1-3.3.2 Design for maintainability.- The AWOS shall be designed for simplicity and ease of maintenance as follows:

(a) The sensors and other replaceable units shall be designed for plug-in or screw-in replacement. All designs shall incorporate a locking technique, an error-free plug-in design and high quality (gold plate) connectors for reliability.

(b) Electronic subsystems shall contain functional modules (printed circuit assemblies) to facilitate rapid replacement. All electronic and mechanical equipment and components shall be designed and constructed for card-level on-site replacement maintenance.

(c) The Universal Circuit Board concept may be implemented by identifying a plug-in (or socket) EPROM (containing site-specific data) as a separate Line Replaceable Unit (LRU).

(d) All electronics modules shall employ a positive locking mechanism to secure modules into the chassis. These mechanisms shall be standardized to facilitate rapid replacement of failed items, and shall be of the type that mechanically draw the module into the system chassis, and secure it during operation.

(e) Each assembly shall be removable from its chassis without requiring the complete removal of any other subassembly. Each chassis and its enclosure shall be of high-quality, sturdy construction that will withstand shipment by common carrier, installation, and use of the equipment.

(f) The AWOS shall continue operating during on-site routine (i.e., periodic) maintenance.

(g) All maintenance functions possible to be performed at one MDT location (DCP or DPU) shall also be possible at the other MDT location.

(h) Archived maintenance data (paragraph 12-2.2.1.5) shall be available on-site through the OT and the MDT, and remotely through the RMMS.

1-3.3.3 General hardware requirements.- Rack-mounted DPU's shall be provided with slides where necessary to permit withdrawal for servicing. Where components or test points are only accessible from the bottom, a suitable tilt or hinge arrangement shall be provided to permit easy accessibility. The system shall be designed so that all alignments, adjustments and routine maintenance require only a single technician. All cables and wires, harnessed or single, shall be protected against chafing. Such protection shall be independent of the individual wire or cable insulation jacket. Workmanship shall be in accordance with MIL-STD-454, Requirement 9.

It is the policy of the FAA in metric conversion to pursue and promote an orderly changeover to the metric system of measurement. FAA-ORD-1020.1, Transition to the Metric System, describes the policies and guidelines to be implemented in the AWOS program.

1-3.3.3.1 Solid-state design.- All electronic circuit designs (except display CRTs) shall use semiconductor, microelectronic devices and discrete components only. Miniature, sealed relays are permitted for power failure detection. Digital circuit design shall be used in preference to analog circuits. Each assembly or subassembly shall have readily accessible test points or a test capability through the MDT. Care shall be exercised to assure that the circuits are highly reliable and utilize commercially acceptable heat transfer techniques (cooling fans shall not be used).

1-3.3.3.2 Printed circuit boards.- All printed circuit boards and circuit card assemblies shall be designed for testing by a tester (paragraph 1-3.3.3.14). All printed circuit boards and circuit card assemblies used shall be of the plug-in card type and shall be identified or keyed to prevent incorrect insertion. The connector pin selection for power and signals shall be such as to prevent any circuit damage in case the key is inadvertently removed and the card or board incorrectly inserted. When installed, the component side of each board shall face the same direction. Two printed circuit board/card extenders of each type and size used at a location shall be furnished with each complete set of equipment. Use of ribbon cables shall be limited. When used, ribbon cables shall be of sufficient length to use extender boards. A provision shall be incorporated to store the board/card extenders in the equipment unit with which they are used. Sockets (e.g., required for site-specific EPROMs) may be used on printed circuit boards if all connection points have a minimum of 50 millionths of an inch gold plating. Sockets shall be considered only where the removal feature compensates for the possibility of reduced reliability. All printed circuit boards for use in equipment installed outdoors shall be conformally coated in accordance with MIL-I-46058 or shall have a suitable technique for corrosion prevention.

1-3.3.3.3 Power indicators and fuses.- Fuses shall be easily accessible and readily replaceable. An indicating fuseholder (or some other means) shall be provided to indicate the status (i.e., good, bad) of each fuse. Indicator lamps shall be provided on the front of each indoor cabinet to show when the power is on. Fuses and indicators shall be replaceable from the front of the equipment.

1-3.3.3.4 System grounding.- A common system grounding design shall be used for each subsystem. The system grounding design must ensure the safety of maintenance personnel when they are operating or testing the system, and the design must be compatible with that of other equipment which interfaces with this system. All surfaces of items on the front of panels shall be at chassis-ground potential.

1-3.3.3.5 Lightning Protection.- AWOS equipment shall be protected against damage or operational upset due to lightning-induced surges on all sensor input lines, sensor supply lines, incoming power and data communications lines. The requirements in this paragraph are to protect the system, equipment (to include electrical circuits of fiber optic modems) and personnel from lightning currents and voltages; from power line transients and surges; and from other electromagnetic fields and charges. The basic requirements of FAA-STD-019 and FAA-STD-020 apply and supplement the requirements herein.

Fiber optic cables are not susceptible to lightning and other forms of electromagnetic energy, and are excluded from the requirements of this paragraph.

1-3.3.3.5.1 Lightning protection systems.- Lightning protection systems shall be designed and installed for all equipment and structures. Where existing structures such as poles, towers and shelters are used, the lightning protection systems already in place shall be upgraded as necessary for compliance with this specification. Intrafacility (building) RS-232/449 data lines between the DPU and the OT, CVD or MDT will not require additional lightning protection. Power lines to commercial equipment (specifically, the operator terminal, controller video display and the MDT) shall not require additional lightning protection. Upgrading of existing lightning protection systems for main (e.g., ATCT or TRACON) buildings shall be the responsibility of the FAA.

1-3.3.3.5.1.1 General.- Lightning protection systems shall be designed and installed in accordance with the Lightning Protection Code, NFPA-78, and the specific requirements given herein.

1-3.3.3.5.1.2 Design.- During the Contractor's Site Engineering Report (CSER) as defined in the contract, requirements for the upgrading of existing lightning protection systems and the installation of new protection systems shall be defined. Detail designs shall be submitted for FAA approval before installation.

1-3.3.3.5.1.3 Cone of protection.- All equipments, including antennas, sensors and obstruction lights, that are pole, tower, or roof mounted shall be within a maximum 45° cone of protection provided by one or more air terminals. In high lightning areas the FAA may require a 30° cone of protection where it can be provided at minimum additional cost. Pad mounted equipments in steel enclosures, such as transformers, do not require air terminals. The cone of protection requirement does not apply to shelters and buildings, except for roof mounted equipments.

1-3.3.3.5.1.4 New shelters.- All new shelters for electronic equipments shall use sheet steel material in the construction of the roof, all outside walls, and entrance doors to protect equipments and wiring in the shelter from lightning and environmental interference and to minimize the radiation of interference to other systems. The steel sheets shall overlap and be connected (bonded together) using conductive metal fasteners.

1-3.3.3.5.1.5 Towers.- Wind sensor and antenna towers and masts shall be protected by a single air terminal and a single down conductor connected to the earth electrode grounding system. The structure of steel poles, masts and towers may serve the function of down conductors provided that air terminal and grounding cable connections are made as defined herein.

1-3.3.3.5.1.6 Movable platforms.- Where platforms with a metal supporting structure that can be raised and lowered are used for pole or tower mounted equipment, detail designs shall be submitted for lightning protection, grounding the platform structure, and maintaining the grounding and shielding continuity of the conduit used to enclose signal and power conductors. Designs may use the fixed steel structure of the tower as the main lightning down conductor. The moving structure shall be inherently bonded (electrically) during assembly by welding or bolting of clean, bare metal surfaces. When in the raised position, all mechanisms providing support, retension or alignment shall be designed to conduct secondary lightning currents and to ground the movable structure to the fixed tower structure. All signal conductors and electric power wiring on the moving platform and on the fixed structure shall be installed in steel conduit. When the platform is erected to its highest position, the shielding and grounding continuity of the conduit shall be maintained by beryllium copper spring contacts about the circumference of the conductor pins and contacts. A sleeve shall extend downward further enclosing and shielding the conductor pins and contacts. Alternate design features providing equal or better grounding, bonding, shielding, and lightning protection may be submitted for approval by the FAA.

1-3.3.3.5.1.7 Materials.- All materials provided and installed shall be UL approved for the purpose except where specific requirements or exceptions given herein apply.

1-3.3.3.5.1.7.1 Air terminals.- Air terminals shall have blunt or pointed ends as specified by the cognizant FAA region or airport office. Also, subject to FAA approval, copper clad steel ground rods with a 3/4 inch or larger diameter may be used as air terminals for poles and towers to minimize damage and replacement of more frailable standard air terminals. When required by the FAA, the pointed end of ground rods shall be ground off, polished and coated with a protective paint or finish. The structural mounting, extension, and bracing of air terminals and ground rods used as terminals shall be designed by the contractor and approved by the FAA.

1-3.3.3.5.1.7.2 Down conductors.- Where a separate down conductor is provided, a soft drawn, stranded, bare copper cable weighing approximately 215 lbs. per 1,000 feet shall be installed for poles and towers less than 60 feet high excluding air terminals. A larger, but otherwise identical cable, weighing approximately 280 lbs. per 1,000 feet shall be installed for poles and towers 60 feet or more in height. Down conductors shall always be routed in a downward direction and bends shall have an 8 inch or greater radius. Mechanical attachments to the pole or tower approximately every 3 feet shall be provided. If a steel pole or tower structure is used as the down conductor, the air terminal shall be directly connected to the tower primary structure or a main size down conductor shall be used to interconnect the lower end of the air terminal to the tower primary structure. The legs or supports at the base of all steel towers shall be directly connected to the earth grounding system using a main size lightning conductor, welded studs or bolt-through base plates with welded studs, and crimped connections.

1-3.3.3.5.1.7.3 Connections.- Substantial electrical and mechanical connections are required between air terminals and down conductors and between down conductors and the below grade earth electrode grounding system. Below grade connections to the earth electrode grounding system shall be made by a hand-hydraulic compression crimping tool with dies and fitting sized for the purpose. Compression crimped connections shall also be used above grade except where bolted connections are indicated. Bolted connections shall use steel clamps and bolts or heavy duty bronze clamps and stainless steel bolts. Bolted connections shall resist a 400 pound pulling force or the tensile strength of the conductor, whichever is less. Non-conductive faying surfaces shall be removed before clamping and a protective coating shall be applied after bolts are torqued.

1-3.3.3.5.2 Earth electrode grounding systems.- New earth grounding systems shall be provided and installed or existing grounding systems shall be upgraded as necessary for compliance with the requirements given herein. Modification or updating of earth grounding systems at main buildings shall be the responsibility of the FAA.

1-3.3.3.5.2.1 General.- Earth electrode grounding systems are required to dissipate lightning currents and electrical fault currents and serve as an equal potential ground reference for all collocated equipments. Earth grounding systems shall consist of driven ground rods or buried plates, and buried interconnecting cables. All site grounding conductors, including equipment, power, telephone, structure, and lightning down conductors, shall terminate or directly connect to the earth grounding system. Below grade metals including fuel tanks, utility piping and conduit shall be directly connected to the earth grounding system. Adjacent earth grounding systems within 30 feet of each other shall be interconnected by buried cables.

1-3.3.3.5.2.2 Design.- The detailed requirements for new earth grounding systems and for the upgrading of existing systems shall be determined during the CSER as defined in the contract. Designs shall be submitted by the contractor and approved by the FAA prior to installation.

1-3.3.3.5.2.3 Poles and towers.- The "standard" earth electrode grounding system configuration for poles and towers shall depend upon the geological conditions at the site. Where soil conditions permit, coupled ground rods shall be driven to a depth of 30 feet at one location; to a depth of 20 feet at each of two locations; or to a depth of 10 feet at four locations. For locations with shallow soil over rock, four copper grounding plates shall be installed. The deeper driven rod configurations shall be used as allowed by geological conditions and power rod driving equipment. Grounding plates shall not be used when rods can be driven at least 10 feet deep. One of the rod or plate locations shall be immediately adjacent to the down conductor for the pole or tower.

1-3.3.3.5.2.4 Local conditions.- Variations to the "standard" earth electrode grounding system for poles, towers and other structures may be required by the FAA based on local conditions including soil resistivity, frequency of lightning damage, size and height of the structure, criticality of equipments, existing buried metals, and adjacent grounding systems. More extensive earth grounding systems may be justified in areas with high soil resistivity and frequent lightning damage. In certain locations a sacrificial anode may be required. Bentonite or other grounding supplements may be needed. Under the most favorable conditions, i.e., low soil resistivity and rare lightning damage, the minimum earth electrode grounding system for an equipment pole or tower shall consist of coupled ground rods driven to a depth of 20 feet at the base of a pole or tower.

1-3.3.3.5.2.5 Ground rods.- Ground rods shall be copper clad steel, UL approved, 10 feet minimum length, 3/4 inch minimum diameter and pointed or coupling type as necessary. Longer rods, or rods with a 1 inch diameter may be used for additional structural strength. The tops of driven rods shall be at least 18 inches below grade. The separation between rods installed at different locations at a site shall be at least equal to their driven depth and preferably twice their depth where space permits.

1-3.3.3.5.2.6 Ground plates.- Grounding plates shall be 20 gage or thicker sheet copper and 2 feet by 2 feet in size. Compression crimped cable connections shall be made to a stud on a top bonding plate that is bolted through the ground plate (copper sheet) and reinforced by a bonding plate on the opposite side.

1-3.3.3.5.2.7 Grounding conductors.- Grounding cables used to interconnect ground rods or plates shall be bare copper and sized the same as the largest down conductor required for the site. Grounding cables shall be installed a minimum of 18 inches below finished grade.

1-3.3.3.5.2.8 Guy wires.- All steel materials used to anchor guy wires such as driven anchor rods, or steel inserts and reinforcing steel in concrete anchors, shall be interconnected using split bolt connectors and No. 6 bare copper grounding wire. Similar bonding jumpers shall be connected around guy wire couplings and fittings.

1-3.3.3.5.2.9 Foundations and supports.- Where driven poles or foundation piers are required to support poles or towers, earth grounding cables shall be installed. Before poles are driven, the cable shall be mechanically fastened the length of pole; to the bottom end; and every 5 feet minimum up the other side. Where drilled foundation piers are required, a grounding cable shall be dropped into the hole with 5 feet excess at the bottom. For both driven poles and piers the other end of the cable shall be secured at grade level for subsequent connection to the down conductor and to the base of steel towers. Grounding cables shall be same size as the lightning down conductor for the pole or tower.

1-3.3.3.5.2.10 Pad mounted transformers.- The enclosures of pad mounted transformers shall be grounded by buried cable interconnection to the site earth electrode grounding system. Alternately, one or more ground rods may be installed at the pad and interconnected to constitute part of the requirements for the site earth grounding system. If an earth grounding system is not within 30 feet or reasonably close, a single ground rod shall be installed and a No. 6 bare copper wire shall be used to ground the transformer enclosure.

1-3.3.3.5.2.11 Grounding of concrete reinforcing steel.- Reinforcing steel (rebar) used in foundation piers, pads, and slabs shall be bonded and grounded. A No. 6 bare copper wire shall be connected to each piece of rebar using split bolt connectors or compression crimped fittings and terminated to a ground rod or buried grounding cable using a compression crimped fittings. For pads or slabs with a dimension greater than 4 feet, two or more wires shall be brought out and connected to a grounding rod or cable.

1-3.3.3.5.3 Grounding.- Grounding shall be provided and installed to conduct lightning currents, power faults, and unbalanced currents; and to eliminate static and electromagnetic charges. In addition grounding shall provide an equal potential reference for the operation of equipments.

1-3.3.3.5.3.1 General.- All metallic structures, enclosures, conduit, cable armor, and conductor shielding shall have a direct, identifiable path to the earth electrode grounding system. The grounding path shall be provided by a separate grounding conductor or by bonding metallic structures or enclosures with a separate conductor to the earth electrode grounding system. All grounding conductors shall be routed as directly as possible without loops, excess length, or sharp (less than 8 inch radius) bends. To be effective over the useful life of equipments, all grounding connections shall be bonded in accordance with paragraph 1-3.3.3.5.4.

1-3.3.3.5.3.2 Equipment grounding.- All equipment enclosures, housings, cases, cabinets, and racks, including electrical power panels, shall be grounded by an equipment grounding conductor provided and installed in accordance with the National Electrical Code (NEC), NFPA-70, except that conduit and other power circuit enclosures shall not be used to serve the purpose. A separate equipment grounding conductor shall be provided and installed with each power circuit.

1-3.3.3.5.3.3 Neutral grounding.- The neutral conductors for power circuits shall not be grounded in or by any equipment or at any point in the system except at service entrances as defined by the NEC. At service entrances and at main disconnect circuit breaker boxes serving the purpose, the power neutral conductor and the equipment grounding conductor shall be common and connected directly to the earth electrode grounding system. The grounding electrode conductor shall be unspliced and routed separately without loops, excess length, or sharp (less than 8 inch radius) bends.

1-3.3.3.5.3.4 Signal grounding.- All signals (including DC power voltages and data, control, monitoring, communication and transmission signals) transmitted by interface lines or landlines shall be balanced 2-wire signals or an individual ground return conductor shall be routed with each signal. A third wire may be routed with 2-wire signal lines to serve as ground return or reference. No device, sensor or equipment that requires an isolated or independent signal grounding system shall be furnished or used in the system. The outer conductors for all coaxial, twinaxial and triaxial cables shall be grounded at equipments, antennas, and bulkheads, and not isolated at any point. Digital signals may be routed with a single common or ground conductor between assemblies within the same enclosure, including cabinets and racks, when the application has previously proven acceptable and no problems are incurred for this system at airport environments.

1-3.3.3.5.4 Bonding.- Bonding is the mechanical and electrical connection of metal materials, wires and cables for the low impedance conduction of currents and electromagnetic energy. The effectiveness of lightning protection, transient protection, grounding, and shielding depends upon the quality of bonding connections.

1-3.3.3.5.4.1 General.- Requirements for specific bonds and the types of acceptable connections are indicated in other paragraphs and parts of this specifications. The detailed requirements for implementing these and other bonding connections are given herein.

1-3.3.3.5.4.2 Preparation.- All surfaces to be bonded shall be clean and free of rust, corrosion and oxidation. All non-conductive paint or finishes shall be removed by spot facing or other suitable methods.

1-3.3.3.5.4.3 Materials and hardware.- All metals requiring bonding shall be steel or copper and alloys of steel and/or copper. Where bonding connections to aluminum are necessary, bimetallic connectors designed for the purpose shall be used. All hardware and materials shall be compatible and plated as necessary to resist corrosion for a minimum of 20 years in outside environments.

1-3.3.3.5.4.4 Connections.- All bonding connections shall be mechanically and structurally adequate. All below grade connections shall be made using a power or hand-hydraulic compression crimper using dies, fittings, and procedures provided by the manufacturer. A conductive oxide inhibitor-contact aid shall be used with all compression crimped connections. Where indicated elsewhere, above grade connections shall also use compression crimped fittings. All bolted clamps and fittings shall be torqued to within 10% of their maximum rating. Welded or bolted and brazed connections are superior to clamped connections and shall be used whenever the structural integrity of the materials is not degraded.

1-3.3.3.5.4.5 Conduit threads and fittings.- All threads for conduit couplings, fittings and terminations installed above and below grade shall be coated with a conductive oxide inhibitor-contact aid. All conduit couplings, fittings and terminations including locking nuts shall be securely tightened. Watertight connections including bushings or washers shall be used for conduit terminations to equipment enclosures; however, these connections shall also provide positive electrical bonding and grounding of the conduit and fitting to the enclosure. Where superior moisture proofing is necessary, an industrial or military grade of RTV rubber sealing compound shall be used as a sealant for conduit fittings and connections.

1-3.3.3.5.4.6 Refinishing.- After bonding connections are made, clamps, hardware, and the exposed edges of faying surfaces shall be coated, painted or refinished to match the surrounding area.

1-3.3.3.5.5 Shielding.- Shielding shall be provided to protect equipment and interface lines from lightning currents and the electromagnetic fields produced by lightning current and discharges. In addition, shielding shall provide for the containment of interference and signals produced by equipments and to protect susceptible equipments from radiated environmental signals and interference.

1-3.3.3.5.5.1 External interface lines.- Interface lines include all signal, data, control, monitoring and power lines and cables. All lines and cables installed on poles and towers and between collocated equipments shall be in rigid steel conduit. Not more than two feet of liquid tight flexible metal conduit (NFPA No. 70) may be installed (using approved grounding fittings on both ends) at each end of the rigid steel conduit to provide the adaptability necessary to install and maintain some equipments. The conduit shall be terminated to the outer enclosure of external equipments and to steel bulkhead entrances at shelters and buildings. All steel bulkheads and enclosures shall be directly grounded to the earth electrode grounding system for the site. Interface lines between equipments separated by external runs of 100 feet or more are further defined as landlines and do not necessarily require continuous steel conduit.

1-3.3.3.5.5.2 Landlines.- The requirements given herein apply to all new and existing landlines used for the system. All landline cables not routed in continuous steel conduit shall have steel armor for mechanical protection, for electromagnetic shielding, and for the conduction of lightning currents that would otherwise couple to conductors. New armored cables shall be selected for superior dialectric breakdown and electric insulating properties of the outer jacket and covering for conductors. Twisted conductors and shielding, such as wire mesh or metal foil, shall be specified as necessary to eliminate interference.

1-3.3.3.5.5.2.1 Landline splices.- Where splices are necessary or exist, the shielding continuity and coverage at the splice shall not be less than provided by the unspliced armored cable. Splicing materials and methods shall maintain the electrical continuity and circumferential coverage for the armor and all internal metal tape and wire mesh shielding. The cable insulation and dielectric properties shall also be maintained at splices. Steel boxes may be used with the armor terminated at both ends using UL approved armor grounding fittings and the splicing accomplished inside. Splice boxes shall have an outside ground stud with a No. 2 bare copper cable interconnected to an adjacent 10 foot ground rod. Connections shall be made by compression crimped fittings.

1-3.3.3.5.5.2.2 Landline entrance conduits.- Buried steel conduit shall be installed for the approach and entrance of armored landlines at poles, towers, and pad mounted equipments, and at shelters and buildings. The conduit shall extend from shelters, buildings and external equipments for a minimum of 10 feet outside any earth electrode grounding cable installed or planned for the facility or equipment site. At least one direct connection shall be made between the conduit and the earth electrode grounding system using No. 2 bare copper cable, a conduit bonding clamp, and a crimped connection to the earth grounding system.

<u>1-3.3.3.5.5.2.3 Landline conduit and armor termination</u>.- Landline conduit and armor shall be terminated at shelters, buildings and outside equipment sites. Terminations shall be made to heavy gage steel boxes, enclosures, or bulkhead type plates that are directly connected to the earth electrode grounding system. Connectors and fittings that are UL approved for the purpose shall be used. Termination boxes, with the conduit terminated to one end and the armor terminated on the inside to the opposite end, may be used. After the conduit is terminated, the armored cable shall not be weather exposed, and after the armor is terminated, the conductors shall not be exposed. If external routing is necessary, the armored cable and conductors shall be treated as interface lines and routed in continuous steel conduit. If compartmentalized equipment enclosures are used at external sites, the conduit shall be terminated to the outside of the enclosure and the armor shall be terminated in a separate internal compartment. Similar termination and separation shall be provided for overall braid or tape shielding as necessary to eliminate interference coupling.

<u>1-3.3.3.5.5.3 New signal landlines</u>.- Fiber optics lines shall be recommended by the contractor in the CSER where the advantages provided by fiber optics technology will provide a cost-effective installation. Where fiber optics lines are not recommended in the CSER (and approved by the FAA), landlines shall be used.

<u>1-3.3.3.5.5.4 Use of existing metallic landlines</u>.- Prior to the use of existing landlines for a new system, they shall be thoroughly tested and inspected, the cost of refurbishment shall be established, and their remaining useful life shall be projected in the CSER. When the life cycle costs of using, refurbishing and eventually replacing existing metallic landlines is excessive, new fiber optic landlines shall be installed.

<u>1-3.3.3.5.5.5 Testing and evaluation of existing landlines</u>.- Only landlines with steel armor with minimum splices and discontinuities shall be considered for AWOS system use. Their exact location and routing shall be determined by energized cable locators, tone tracers, or other methods as applicable. Markers shall be installed and drawings revised to reflect their exact location. Extraneous signals, currents, and 60 cycle pickup shall be measured to define open circuit parameters at both ends. Measurements shall be repeated with resistive terminations at one end and at both ends. Other testing, including rf checks for coaxial and similar cables, shall be performed as applicable. If testing and inspections show the landlines are adequate, all splices and terminations shall be reworked and handholes and manholes cleaned out and refurbished as necessary.

1-3.3.3.5.5.6 Protection of existing landlines.- Prior to any digging, trenching, excavating, or earth work in an area, the exact location of any signal or power lines shall be determined, staked, and shown on plot plans. All digging and trenching within 3 feet of any line location shall be done manually and in the presence of a regional FAA engineer. All insulation nicks and cuts shall be properly repaired. Any line or cable cut shall be spliced in accordance with the requirements herein. If requested by the regional FAA engineer, a permanent splice shall be installed. All buried lines and cables exposed during work performed shall be examined by the regional FAA engineer prior to covering or backfilling.

1-3.3.3.5.6 Conductor segregation, separation and routing.- The segregation, separation and routing of all lines, cables and conductors shall be designed by the contractor to minimize the coupling of lightning currents, transients, surges, and interference.

1-3.3.3.5.6.1 General.- All AC power lines, signal lines, and grounding cables shall be segregated and routed separately and not installed in the same trench or conduit. The parallel routing of these types of cables shall be avoided and, where necessary, shall conform to NFPA-78 code. To the extent feasible, all crosses shall be at right angles.

1-3.3.3.5.6.2 A.C. power lines.- At equipment sites and facilities, the AC power lines to service entrances shall be kept separate from all subsequent feeders and circuits and the power circuits fed by power conditioning systems shall be kept separate from other (non-conditioned) feeders and circuits. Inside equipment enclosures, power lines shall be as short as possible and routed separately from signal lines.

1-3.3.3.5.6.3 Signal lines.- High and low level signal lines shall be segregated and routed separately or adequately shielded to prevent interference, degradation of data, and operational upset.

1-3.3.3.5.6.4 Grounding cables.- For purposes of segregation and separation, grounding cables primarily include down conductors and buried earth electrode system cables. Equipment grounding conductors which are routed with power circuits are excluded. On poles and towers where limited alternatives exist, preference shall be given to routing both signal and power conduits as far as practicable from the down conductor cable with the tower steel structure between the down conductor and the signal and power conduits.

1-3.3.3.5.7 Transient and surge suppression.- All transient and surge arrestors, suppressors, circuits and components required for the system and equipments shall be furnished and installed by the contractor except for the suppressors required at service entrances to buildings, shelters and for collocated field equipments. These service entrance suppressors shall be Government furnished and installed by the contractor.

1-3.3.3.5.7.1 Transformers.- Secondary distribution and other free-standing or mounted transformers furnished with the system shall have primary and secondary arrestor or suppression units to protect the transformer windings and circuits and to further reduce the transient and surge levels conducted to service entrance equipment.

1-3.3.3.5.7.2 Service entrances.- Where service entrance equipment is installed by the contractor, the installation of an FAA approved suppressor unit will be required. The service lines from the transformer pole or pad to the service entrance enclosure shall be routed below grade in steel conduit. The service entrance enclosure shall contain a main disconnect breaker. The service lines shall then be routed from the main disconnect breaker to the suppressor enclosure and connections and then to a circuit breaker enclosure if two or more separate power circuits are required. Steel conduit fittings and nipples shall be used for interconnections between the main disconnect, suppressor, and circuit breaker enclosures.

1-3.3.3.5.7.3 Transient suppression for landlines.- Transient suppression circuits or components shall be provided and installed for each landline to protect equipments and comply with the electromagnetic interference (EMI) and spike test requirements of this specification. Transient suppression circuits and components shall not degrade the operation or performance of equipments. Optical isolators shall be used where feasible and will serve to minimize requirements for suppression circuits and components. Suppression components, used singularly and in combination, may include varistors, large junction avalanche zener diodes, resistors, inductors, and capacitors. Suppression components shall be selected and circuits designed to clamp and limit transient voltage and energy to levels below the damage, degradation or upset levels of equipment circuits connected to landlines. All spare or unused landline conductors shall be grounded at both ends.

1-3.3.3.5.7.4 Transient suppression for interface lines.- Interface lines include all types of signal and power lines routed between equipment enclosures at equipment sites. Certain types of equipments produce transients and interference as a result of their normal operation. Other types of equipments and circuits are inherently susceptible to conducted transients and interference. These equipments shall have transient and interference suppression components, devices or circuits installed internally and/or at interface conductor connections. Suppression components and circuits shall not degrade the operation and performance of equipments. Suppression components, as identified for landlines, shall be selected and circuits designed to limit conducted transient and interference levels and protect susceptible equipment circuits.

1-3.3.3.5.7.5 Transient suppression for antenna lines.- Transceivers and rf link equipment circuits shall be protected from transients resulting from near proximity lightning strikes and cloud to cloud discharges. Transient suppression components or circuits shall be selected or designed and incorporated by the equipment manufacturers. All specification, performance, operation, and acceptance testing performed by the equipment manufacturer and by the system contractor shall be accomplished with transient suppression components or circuits installed. As necessary, preliminary testing shall be accomplished to validate the effectiveness of the suppression and the effect, if any, on equipment performance. Typical suppression component configurations may consist of an in-line blocking capacitor and a fast response minature spark gap connected center conductor to shield or ground. Alternately, a low capacitance varistor connected across a diode bridge to further reduce capacitance may be used if performance is not degraded. Designs shall minimize transient levels and energy and provide impedance matching, minimum insertion loss, and minimum VSWR.

1-3.3.3.6 Electromagnetic Interference (EMI) protection.- The AWOS shall meet the emission and susceptibility standards in MIL-STD-461, as listed (and, in some cases, modified) below:

(1) Conducted Emission (CE03), 20kHz to 50 mHz, input and output power leads.

(2) Conducted Emission (CE03), 20kHz to 50 mHz, control, signal and external leads. The limits for signal leads may be relaxed as necessary to accommodate the spectrum produced by the required signal levels and bandwidths.

(3) Conducted Emissions (CE06), 10 kHz to 10 gHz, antenna terminal.

(4) Conducted Susceptibility (CS01), 15 kHz to 50 kHz, power leads.

(5) Conducted Susceptibility (CS02), 50 kHz to 400 mHz, power leads.

(6) Conducted Susceptibility (CS03), 15 kHz to 10 gHz, intermodulation, receiving equipment.

(7) Conducted Susceptibility (CS04), 15 kHz to 10 gHz, rejection of undesired signals, receiving equipment.

(8) Cross-modulation (CS05), 15 kHz to 10 gHz, receiving equipment.

(9) Conducted Susceptibility (CS06), spike, power leads, 400 volts.

(10) Conducted Susceptibility (CS07), squelch circuits, receiving equipment.

(11) Radiated Emissions (RE02), 14 kHz to 10 gHz.

(12) Spurious and Harmonic Emissions (RE03), 15 kHz to 40 gHz.

(13) Radiated Susceptibility (RS03, except for MIL-Handbook 235 requirements), 14 kHz to 10 gHz, electric field.

1-3.3.3.7 Cable entrance and exit locations.- Cable entrances and exits shall be designed to enable routing of the cables between units from the standpoint of accessibility, non-interference with operating personnel, and appearance of installed equipment.

1-3.3.3.8. Laser Components.- When a laser is designed into the AWOS system, the design shall conform to ANSI STD Z 136.1 with Class 3b maximum accessible emmission level applied to direct viewing without optical instruments (excluding ordinary eyeglasses). An interlock device in the laser power circuit of laser subsystems shall be provided to disable the laser, thereby preventing inadvertent exposure of the laser emission to the eyes of the technician and others when maintenance is performed.

1-3.3.3.9 Safety.- The precautions outlined in Requirement 1 of MIL-STD-454 shall be adhered to in system design and construction to promote maximum safety of both operating and maintenance personnel. All electric power cabling and distribution must be isolated from low voltage power lines and signal lines.

1-3.3.3.10 Human engineering.- The design shall employ human engineering criteria and principles to achieve safe, reliable, and effective performance by operational and maintenance personnel, and to minimize the required personnel skill and training time. Human engineering design shall be included as a subject of the design verification reviews (Paragraph 1-4.3.1.3).

1-3.3.3.11 Motors.- Motors shall be designed for continuous duty and their bearings shall not require lubrication for the lifetime of the motor (a minimum of 5 years).

1-3.3.3.12 Maintenance ports/test points.- The AWOS system shall have test plugs and points and/or maintenance data terminal ports to fully utilize the diagnostic capabilities of the BIT and RMM interface. The AWOS design shall provide for the examination of significant voltages, signal amplitudes, waveforms and timing characteristics and to provide for the connection of test equipment for adjustment and maintenance operations. All test points and connectors for testing of LRU's shall be accessible without the removal of plates or covers, with adequate visibility and clearance from adjacent objects to permit safe and unhampered connection of cables and probes. Test points on plug-in printed circuit boards shall be located on the outside edge of the board. Testing shall be possible to allow diagnostic trouble shooting of electronic equipment without interruption of operation, including grounding of test points. The DPU shall have LCD/LED type indicators or a multipurpose fault display to disclose whether each module is performing its required function. Provision shall also be made in the design for monitoring of parameters through a maintenance data terminal, operator terminal and the RMMS. Adequacy of the test scheme shall be included as a subject of the design verification reviews (Paragraph 1-4.3.1.3).

1-3.3.3.13 Convenience outlets.- Two grounded, duplex, convenience outlets equipped with a ground fault interrupter, individually protected by a circuit breaker, with parallel slots and double sided contacts, rated at 20 amps, 120 volts, 60 Hz, shall be available at each DPU and DCP. These outlets shall be suitable as a source for test equipment and a portable light for the maintenance technician's use.

1-3.3.3.14 Special tools and test equipment.- The variety and number of special tools required to achieve and maintain the performance characteristics specified for the AWOS shall be limited to the following:

(a) Initial Installation Test and Calibration Equipment

(b) Maintenance Equipment (Field, Sector Work Center, depot level Maintenance)

(c) Installation and Test Support Software/Firmware

(d) Depot Level Software/Firmware

(e) Sensor Test and Calibration Units (Part 17)

(f) Connectors and Cables for the above

(g) Documentation for the above

All equipment, cables and card extenders that are necessary to install, tune, align or calibrate, test or maintain the equipment, shall be provided by the contractor. Special tools and test equipment shall be provided as specified in the contract.

The AUTEK 5810A tester is standard equipment at the FAA Aeronautical Center, Oklahoma City, Oklahoma, and is used for depot-level printed circuit board maintenance. The test programs to utilize the AUTEK 5810A or other tester, shall be provided by the contractor. An AUTEK 5810A tester will be provided as GFE, if required.

1-3.3.3.14.1 Test Programs for Use in Automated Test Equipment.- The contractor shall provide all materials and resources required to generate, test and document Line Replaceable Unit (LRU) and Shop Replaceable Increment (SRI) test programs. These test programs will include full operator prompting instructions and shall be capable of isolating not less than 90 percent of all possible faults located on each digital module provided as a part of the AWOS system. This requirement also applies to any digital portion of hybrid modules.

Each test program shall include a technical data package containing:

(1) Part layout drawings including the reference designations for each part.

(2) Logic diagrams with appropriate reference to the parts layout drawings.

(3) Schematic diagrams for each module.

(4) Printed copy of contents of the automated test programs (both the system executive and the unit under test program object code). Each instruction shall have comments defining its meaning.

(5) Documentation including parts layout and schematics of the circuitry used on the pluggable adapter.

(6) The source code shall be provided, to include comments defining each instruction.

(7) A fully wired and functional pluggable adapter shall be provided for each family of modules or printed wiring boards.

1-3.3.3.15 Communications circuits.- Communications circuits shall be provided between AWOS equipments (e.g., DCP to DPU) and between AWOS equipment and interfacing external systems and equipment (e.g., DPU to

VOR) as described in Parts 1, 11, 12, 19 and 22 of this specification. AWOS equipment interfaces with communications circuits shall be designed to accommodate wire, fiber optic lines, and radio (see Part 22, paragraph 22-2.2.3) The type of circuits to be used at each AWOS installation shall be as specified in the Contractor Site Engineering Report (CSER) as required by the contract.

1-3.3.3.16 System security.- The contractor shall provide hardware and software safeguards to prevent the unauthorized or inadvertent input, change or cancellation of AWOS data. System security shall be a subject in the design verification reviews (paragraph 1-4.3.1.3).

1-3.3.3.17 Outdoor enclosures.- Any electronic equipment to be installed outdoors (paragraph 1-3.2.2.2(b)) shall be designed to operate and survive in an unprotected environment (i.e., the equipment will not be installed in an equipment shelter). The enclosure shall be impervious to intrusion by animals, birds and insects.

1-3.3.3.18 Factory electrostatic discharge (ESD) control program.- The contractor shall establish and implement a factory ESD control program, in accordance with DOD-STD-1686, to minimize the impact of ESD on AWOS reliability and life cycle cost. Maintenance ESD precautions shall be addressed in the appropriate maintenance manual.

1-3.3.4 Service life.- The system shall be designed and constructed to have a operating service life of 20 years with normal maintenance and replacement of failed parts.

1-3.3.5 Size limitations.- The contractor shall develop diagrams showing the exterior dimensions of each subsystem of the AWOS system. These diagrams shall detail any mounting requirement (e.g., the size of the platform upon which a sensor is mounted). Space requirements for some components (especially displays) are critical. Exterior dimensions of AWOS components must be approved by the FAA during the design verification reviews (paragraph 1-4.3.1.3).

1-3.4 Reserved

1-3.5 Reliability/maintainability

1-3.5.1 General.- Reliability/maintainability assurance shall be accomplished in accordance with the guidance in this section and paragraph 1-4 (Quality Assurance). In recognition of the need for reliability, a large number of tests will be performed on the AWOS system. Some of these tests may exceed the operational requirements of this specification. Each test, including those in the contractor's test plan, is necessary to demonstrate quality, accuracy, and reliability.

Definitions

(1) Diagnostics - Diagnostics refers to the Built-in-Test (BIT) and Fault Isolation Test (FIT) features for the determination of subassemblies, boards, parts, etc. that perform below minimum acceptable levels.

(2) Mean Time Between Failures (MTBF) - MTBF is equal to the total operating hours of the equipment divided by the number of system failures.

(3) Mean Time To Repair (MTTR) - MTTR is the mean time required to complete a maintenance action, i.e., total maintenance downtime divided by the total number of maintenance actions during a given period of time, excluding periodic maintenance downtime, and parts supply, administrative and other logistics downtime. "Repair" includes identification of the malfunction, removal of defective component or subsystem, replacement, calibration and restoration to operational status.

(4) Reliability - Reliability is the probability that an item will actually perform its intended function for a specified interval under specified conditions.

(5) Predicted Reliability - Predicted reliability is the reliability of an equipment mathematically computed from its design considerations and from the reliability of its parts in the intended conditions of use.

(6) System Failure - System failure occurs when: (a) the system does not output the voice or data message, (b) there is a communications failure between the DCP and the DPU, (c) AWOS output is not correct (i.e., AWOS output does not represent the weather parameter detected by the sensors), (d) any two weather sensors simultaneously fall out of calibration (as defined by this specification) or are reported missing, and (e) any catastrophic failure.

(7) Subsystem Failure - A subsystem of the AWOS is defined as having failed when it suffers the complete or partial loss of its ability to perform its required function within the accuracies set in this specification.

1-3.5.2 Reliability and maintainability design requirements.- The predicted reliability requirement for the AWOS system is 90 days (2160 hours) MTBF. This total system MTBF shall be the result of a reliability budget that considers the reliability of every AWOS subsystem. The contractor shall maintain this objective throughout the various phases of the program (e.g., design verification reviews, design qualification testing, production testing, etc.). The AWOS system as configured in this specification is assumed to have no built-in redundancy that would affect the MTBF.

The on-equipment, on-site maintainability (MTTR) requirement for the AWOS system and its components shall not exceed 30 minutes, with a 90 percent confidence level.

<u>1-3.5.2.1 Maximum repair time</u>.- Ninety percent of all on-equipment, on-site repairs to the AWOS subsystems (except the microcomputer development system) shall not individually exceed one hour when performed by one qualified and experienced technician.

<u>1-3.5.2.2 Periodic (scheduled) maintenance time</u>.- The AWOS system shall be designed such that periodic maintenance shall not be required on a scheduled basis more often than once every 90 days, and the mean periodic maintenance time (MPMT) shall not exceed four hours. Periodic maintenance tasks shall require the services of only one person.

During the appropriate periodic maintenance visits, the calibration and operation of each sensor and the system shall be verified. The procedures and the required frequency of calibration shall be defined by the contractor, keeping in mind that sensor drift outside of the required specification limits constitutes a failure of the system. Periodic maintenance shall be accomplished without interruption of AWOS system operation.

<u>1-3.5.3 Reliability program</u>

<u>1-3.5.3.1 Reliability requirements</u>.- All equipment provided by the contractor shall be produced under reliability programs which comply with the requirements of MIL-STD-785. They shall be designated to fulfill the requirements of the FAA Order AF 6000.10 Airway Facilities Service Maintenance Program.

<u>1-3.5.3.1.1 Contractor Submitted Reliability Program Plan</u>.- The contractor will submit a reliability program plan (MIL-STD-785, Task 101) which includes as a minimum the following:

(a) Definition of the reliability program goals.
(b) How the reliability goals will be achieved.
(c) Design and construction techniques that will maximize system MTBF.
(d) Predictions of MTBF.
(e) An agenda of items to be covered in design reviews.
(f) How use of failure analysis and corrective action reports will improve and expedite design.

The contractor reliability program plan will enhance the design and establishment of equipment capabilities. The plan so developed will be in accordance with MIL-STD-785 and MIL Handbook 217.

1-3.5.3.1.2 Reliability analysis.- The contractor will conduct reliability analysis in accordance with the provisions of MIL-STD-785 (Task Section 200) and MIL Handbook 217.

The reliability analysis conducted by the contractor will use ground, fixed environmental conditions in the calculations and will be submitted containing the following as a minimum:

(a) A reliability block diagram of the equipment indicating all redundancies, series elements, voting logic, etc.

(b) Failure rates for each element of the equipment, where an element is defined as the lowest level of assembly for which failure rates are available.

(c) Parts selection in accordance with MIL-STD-785.

(d) References of all failure data and modification factors used to account for environmental conditions. Justification of these factors must be based on an engineering analysis.

(e) Estimates of the equipment reliability based on the above requirements.

(f) Documentation and justification of all assumptions concerning the reliability analysis.

1-3.5.3.2 Reliability program review.- The provisions of MIL-STD-785, task 103 apply. Major reliability program checkpoints or milestones on both activities and results (as they become available) shall be defined and integrated into overall system program control procedures. The reliability program reviews shall be conducted in conjunction with the preliminary and final design verification reviews (paragraph 1-4.3.1.3). The FAA shall be notified at least 15 working days prior to each contractually scheduled formal reliability program review to permit participation by the FAA. The minutes of these formal reliability program reviews shall be provided to the FAA.

1-3.5.3.3 Reserved.

1-3.5.3.4 Failure reporting, analysis, corrective action systems (FRACAS) and data collection.- The contractor shall establish and implement a closed loop procedure in accordance with MIL-STD-785, task 104 to: (1) collect data on failures occurring during all phases of his effort, including incoming part inspections, component engineering and debugging, production screening or burn-in tests and reliability acceptance tests; (2) statistically analyze the data to identify reliability problems and to assess the progress made in meeting reliability requirements; (3) perform engineering analyses of failed parts to ascertain the causes of the failures; (4) implement appropriate corrective action to preclude the recurrence of failures experienced; (5) perform follow-on audits as necessary to assure adequacy of corrective action. All data shall be available for FAA inspection.

1-3.5.3.5 Failure summaries - Monthly summary reports of failures shall be submitted to the FAA contracting officer during all phases of testing. They shall include: identification of each failure; equipment failure modes and cause of failure; corrective action recommended; status of corrective action implementation and relevancy related to reliability demonstration test failures. The summaries shall include an analysis showing any trends, patterns, etc., that can be discerned.

1-3.5.3.6 Failures after the Joint Acceptance Inspection (JAI).- The contractor shall continue to perform the requirements in Paragraphs 1-3.5.3.4 and 1-3.5.3.5 after the JAI and until the end of the contract.

1-3.5.4 Maintainability program and manuals.- The contractor shall provide and maintain a maintainability program that will achieve the maintainability objectives (paragraph 1-3.5.2 of this specification).

1-3.5.4.1 Maintainability program.- The required maintainability shall be achieved through a maintainability program developed in accordance with MIL-STD-470, Task 101. The terms and definitions for maintainability not otherwise described or delineated herein shall be in accordance with MIL-STD-721. All electronic and mechanical equipment shall be designed and constructed to minimize skill, experience, and time necessary to disassemble, assemble, and maintain them. Corrective maintenance shall utilize a remove-and-replace concept with actual repair of the replaced module or LRU to be accomplished later in a separate maintenance area.

1-3.5.4.2 Contractor's Maintainability Program Plan.- The contractor will develop, maintain and provide to the Government as a part of this contract a maintainability program plan. The plan as submitted by the contractor will include the following:

(a) Definition of the program goals.
(b) How the goals will be achieved.
(c) Methods of reducing maintenance skills.
(d) Methods of improving maintenance and diagnostic routines.
(e) Techniques for optimizing the frequency and extent of periodic maintenance.

(f) Methods to minimize specialized tools, test equipment, and test programs (software).
(g) Design and construction techniques that will minimize maintenance actions and repair time.
(h) Predictions of MTTR and periodic maintenance
(i) Demonstration test plans.
(j) An agenda of items to be covered in design reviews.
(k) How use of failure analysis and corrective action reports will improve and expedite design.

<u>1-3.5.4.3 AWOS maintenance concept</u>.- AWOS equipment shall be designed to and will meet the requirements of FAA ORD AF 6000.10 Airway Facilities Service Maintenance Program. The contractor shall show compliance during the design verification reviews (paragraph 1-4.3.1.3). AWOS Remote Monitoring Subsystems (RMS) shall be provided by the contractor to interface between the AWOS and the National Airspace System (NAS) Remote Maintenance Monitoring System. The RMS shall fulfill the requirements of NAS-MD-790, Configuration Management Document for the Remote Maintenance Monitoring System (RMMS).

<u>1-3.5.4.3.1 Maintenance program requirements</u>.- The AWOS maintenance concept shall be in accordance with FAA Orders 6000.10, 6000.15, 6000.26, 6000.27, and 6000.30. Some of the areas important to AWOS are:

(a) Automated continuous monitoring
(b) Outdoor electronics in weatherproof enclosures
(c) On-site module replacement
(d) Remote control and status monitoring
(e) Automated record keeping
(f) Remote diagnosis and fault location

<u>1-3.5.4.3.2 Remote maintenance monitoring</u>.- The AWOS shall be designed to comply with NAS-MD-792, Operational Requirements for the Remote Maintenance Monitoring System (RMMS) and NAS-MD-793, RMMS: Functional Requirements for the Remote Monitoring Subsystem (RMS). The purpose of the RMMS is to remotely monitor the AWOS, to detect actual and potential subsystem or system problems or failures, in order that appropriate maintenance actions can be taken while minimizing travel time and onsite maintenance activity. Thus, the AWOS RMMS capability shall isolate system failures so that a maintenance technician can be advised which spare parts are required to service an AWOS. Additionally, the AWOS RMMS shall detect potential component failures so that a maintenance technician can be advised of component replacement requirements to be completed, for example, on a periodic maintenance visit.

The contractor shall establish performance tolerances for the AWOS system, and shall design and implement circuitry to monitor and report the status of the AWOS system and each of its subsystems to the RMMS system. This AWOS circuitry shall include the capability for an RMMS technician to query the AWOS to locate and isolate at least 90 percent of all potential AWOS malfunctions to the line replaceable unit (LRU) level with a 95 percent confidence factor (i.e., 90 percent of all AWOS failures (except for total power failures) shall be identified to the LRU level at least 95 percent of the time). All RMMS diagnostics functions shall be performed locally through the maintenance data terminal and also remotely through the RMMS interface. A description of the AWOS/RMMS interface is in Part 19, paragraph 19-2.2.

1-3.5.4.3.3 Location-oriented maintenance requirements

(a) On-equipment, on-site maintenance is that maintenance done on the equipment as installed. Removal and replacement of faulty modules, module recalibration and software verification shall be the extent of the repair actions. Piece parts repair on replaceable modules is not authorized. Ninety-five percent of all maintenance actions are to be performed by a single technician having the training and experience defined and provided in contractor prepared training courses.

(b) Off-equipment, on-site maintenance is that maintenance done on removed LRU's. It is restricted to easily made repairs of LRU's which do not require special test equipment. Piece part repair of circuit cards is not authorized. Off-equipment, on-site maintenance will be done by the same individual that performs the on-equipment, on-site maintenance.

(c) Off-equipment, off-site maintenance is that maintenance done on removed LRUs at a local work center. It involves testing, fault isolation, and repairs down to the piece-part level which do not require special test equipment. Piece-part repair of circuit cards is not authorized at this level.

(d) Depot level maintenance is that maintenance done on LRU's, circuit cards, assemblies, drawers, cabinets, etc., at the maintenance depot. It involves all levels of testing and fault isolation down to the piece-part level. It also involves any other rework to restore the item to a serviceable condition. A variety of skills and skill levels are required at this level.

1-3.5.4.4 Maintenance manuals.- The contractor shall develop maintenance manuals in accordance with Part 20, paragraph 20-2.3.2.

<u>1-3.5.5 Logistics Life Cycle Cost Analysis</u>.- The Contractor shall perform a logistics support analysis, and a life cycle cost (LCC) for the 20-year economic life of the AWOS system. The cost elements to be separately included in the LCC are:

(a) Sparing cost - cost of initial and replacement spares
(b) On-site maintenance costs
(c) Work center maintenance costs
(d) Depot level maintenance costs
(e) Cost of a Dedicated Repair Service (DRS) option
(f) Cost of special support equipment
(g) Cost of special computer software
(h) Cost of training (See FAA-STD-028)
(i) Cost of management and technical data
(j) Cost of new facilities

<u>1-3.5.6 Configuration Management Program</u>.- The contractor shall establish and maintain a program to assure proper configuration identification, control and accounting throughout the life of the contract. The submission shall include a description of how the contractor proposes to accomplish configuration management in accordance with FAA-STD-021 for all deliverable equipment, firmware, software, spare and repair parts and documentation throughout the contract.

<u>1-3.5.6.1 Configuration Management Plan</u>.- The contractor shall prepare a Configuration Management plan as outlined in FAA-STD-021. The plan shall describe how the contractor intends to assure proper configuration identification, control audits and accounting. The plan shall reflect both hardware and software plans. The contractor shall be responsible for its implementation and application to subcontractors, vendors, and suppliers.

<u>1-3.5.6.2 Configuration Control</u>.- The Contractor shall establish and maintain a configuration management program in accordance with FAA-STD-021 to insure positive control of the configuration of the AWOS and supporting equipment throughout the life of the Contract. This program shall provide for the orderly development and documentation of the details of the configuration of both the hardware and software during the design, development and production phases. The program shall result in an accurate system definition at the completion of design, all required tests, and acceptance of the First Articles by the Government. Upon acceptance of the First Articles, the equipment configuration, including the appropriate descriptive documentation, shall be baselined. Thereafter, the contractor shall submit any engineering change proposal which affects baselined hardware, software or documentation (e.g., instruction books, installation drawing, etc.) to the Government for approval in accordance with FAA Order 1800.8.

Upon approval, all Contractor-initiated change proposals shall be implemented by the contractor in all deliverable equipment or documentation or both, including any previously delivered. If the equipment or documentation has been accepted by the Government, the changes shall be implemented by means of approved Electronic Equipment Modifications (EEM) which are prepared by the contractor in accordance with FAA Order 1320.33. The requirements of this paragraph are applicable to all equipment deliverables under this specification, including off-the-shelf equipment. Any such changes required to bring the item or items into conformance with the requirements of this specification shall be implemented by the contractor.

1-3.5.6.3 Configuration Audits

1-3.5.6.3.1 Functional Configuration Audits (FCA).- The contractor and the Government shall conduct an FCA on the First Articles of each configuration item in accordance with FAA-STD-021 after completion of specification compliance testing. The contractor shall be responsible for the support of the audit in accordance with MIL-STD-1521, Appendix E. The contractor shall prepare and submit agenda and minutes of the FCA to the Contracting Officer within 30 calendar days of the completion of the audit.

1-3.5.6.3.2 Physical Configuration Audits (PCA).- The contractor and the Government shall conduct a PCA on the First Article of each hardware and software configuration item in accordance with FAA-STD-021. The contractor shall be responsible for support of the audit in accordance with MIL-STD-1521, Appendix F. Successful completion of the PCA establishes the product baseline. In the event that the PCA identifies incorrect engineering or technical data, the contractor shall correct the data to conform to the product baseline at no expense to the Government. The contractor shall prepare and submit agenda and minutes of the PCA to the Contracting Officer within 30 calendar days of the PCA.

1-3.5.6.3.3 Configuration Status Accounting.- Configuration Status Accounting shall be in accordance with the approved Configuration Management Plan. The Contractor shall comply with the requirements of FAA-STD-021 for reporting the accomplishment of updating retrofit changes to equipment and computer programs. These items shall be delivered to the Contracting Officer within 30 calendar days of the date of changes.

1-3.6 Logistics Support.- MIL-STD-1388-1, MIL-STD-1338-2, and MIL-STD-1561 shall be the basic requirements documents for logistics support. Specific deliverables and tasks required by these documents will be defined in the contract.

1-3.6.1 Availability of parts and components from more than one manufacturer.- The AWOS design shall use parts and components that are available from two or more sources of manufacture. As a minimum, all electrical and electronic components shall have at least two independent sources of manufacture, or be available through the Department of Defense supply system.

1-3.6.1.1 Parts available from more than one manufacturer.- It is recognized that parts and components from different manufacturers may not be exact duplicates. However, they must be functionally interchangable, (i.e., same performance, reliability, and maintainability). The equivalent item may differ physically from the primary design in that installation may require operations such as cutting, drilling, reaming, filing, shimming, etc., in addition to the normal methods of attachment. Any exceptions must be submitted in writing with full justification, explaining why the exception is to the advantage of the FAA. The FAA shall be the final decision authority for granting any exception.

1-3.6.1.2 Availability of parts from The Department of Defense.- There is a requirement to conduct a screen of the manufacturer's part numbers against the Defense Logistics Services Center (DLSC) central files by the use of Electronic Data Processing Equipment (EDPE) for the purpose of revealing National Stock Numbers (NSNs). The contractor shall provide to the Government the data necessary to conduct the DLSC screen.

1-3.6.1.3 Guarantee of parts availability.- The prime contractor shall be required to guarantee repair/spare parts availability for a period of seven years. Additionally, the contractor shall be required to guarantee the availability for seven years of repair parts supplied by subcontractors.

1-3.6.1.4 Standards for establishment of parts equivalency.- The contractor will describe the standards that will be applied to insure parts equivalency. The contractor has the responsibility to insure that parts offered from alternate sources meet the requirements for the application intended.

1-3.6.2 Accessibility of parts.- All parts and other components shall be mounted in such a manner that they are accessible to permit maintenance personnel to comply with the Mean-Time-To-Repair (MTTR) requirements of this specification.

1-3.6.3 Furnishing of removable parts and a spares kit.- Each system furnished by the contractor shall be complete with an installed set of fuses, pilot lamps, crystals, ferrule-type resistors, air filters and any other parts which are used in the equipment. Spares shall be provided as specified in the contract.

<u>1-3.7 Finishes</u>.- The coatings and finishes applied to the system or any component thereof shall be designed to prevent corrosion or electrolysis of metal for the design life of the system (paragraph 1-3.3.4), recognizing that exterior painted surfaces of equipment installed outdoors (para. 1-3.2.2.2.(b)) may have to be recoated every five years. Coatings and finishes that do not adhere to the base metal or material, or which have runs, drips, cracks, blisters, pits, chips, flaking, scratches or other imperfections shall not be acceptable.

Metal surfaces of equipment installed indoors (para. 1-3.2.2.2(a)) shall, as a minimum, be given a protective finish as specified in the following subparagraphs.

<u>1-3.7.1 Front surfaces of exterior metallic surfaces</u>.- The front face and edges of exterior front panels and panel doors, and the exterior surfaces of equipment cabinets, portable cabinets, and all other final metallic enclosures, including the doors thereof and exterior trim strips, shall be finished by applying one or more uniform spray coats of a baking primer; followed by application of one or more uniform spray coats of a hard lusterless alkyd baking enamel or epoxy paint. The basic color and accent panel colors shall be as specified by the FAA Contracting Officer from the colors normally offered by the manufacturer.

<u>1-3.7.2 Back surfaces of exterior metallic surfaces</u>.- Exterior front panels and panel doors finished as specified in 1-3.7.1 above shall have their back surfaces finished in one of the following ways: same as front surface; or with a baked primer (only) which is the same color as the front surface; or as specified in paragraph 1-3.7.3 below for interior aluminum surfaces.

<u>1-3.7.3 Interior aluminum surfaces</u>.- The chassis, interior panels, and other interior surfaces of aluminum and aluminum alloy (except castings) shall be thoroughly cleaned by an alkaline dip or equivalent process so as to produce an etched surface. After etching, an additional treatment which will protect the surface from finger-marks shall be applied.

<u>1-3.7.4 Other interior metal surfaces</u>.- All interior metal surfaces of the equipment structure (other than stainless steel and monel) not covered above shall be protected by a durable coating of enamel, or by a protective electroplating.

<u>1-3.7.5 Plated finishes</u>.- Where electroplating is employed as a finish, it shall be equal to the best commercial grade, using a plating thickness adequate for protection of the parts under conditions of their use in service. Flash platings, platings with base metals or underplatings showing through, or platings which are pitted or give evidence of flaking or peeling, are not acceptable.

1-3.7.5.1 Cadmium plating.- Cadmium plating shall not be used if it is in direct contact with, or located in confined spaces adjacent to waxes, phenolics, or other organic materials which will react with the cadmium to cause "growth" or the formation of cadmium soaps.

1-3.7.5.2 RF conductivity platings.- Cadmium (when required for EMI gasket surfaces), silver, gold, or rhodium electroplating may be used where required for reasons of conductivity. Connectors on equipment installed outdoors shall be non-corrosive with gold plated contacts. Where silver plating is used, the plating process shall be such as to insure a minimum thickness of 0.0005 inch. In addition, the silver plating shall be given a clear chromate conversion coating for solderability and tarnish resistance. The chromate conversion coating shall be omitted on silver-plated surfaces where contact requirements are such that an increase of 15 percent in surface contact resistance cannot be tolerated.

1-3.8 Ventilation and cooling.- Forced ventilation systems shall not be used for cooling within electronic equipment enclosures without approval of the FAA.

1-3.9 Marking.- All markings shall be permanent and legible. All subsystems, parts or components (including PCB and module cards) shall be marked with a part number or other identifying characteristic. All parts or components which have labels or markings carrying identifying data or ratings should be mounted so that the data are visible to maintenance personnel without the necessity for disassembly of the part or adjacent functional or structural parts. This requirement shall be mandatory whenever it can be applied by the contractor without purchasing made-to-order parts with special markings, and where it can be applied without preventing the use of normally compact assemblies of parts on chassis, such as side-by-side mounting of metal-cased capacitors, or other normal methods of assembly.

1-3.9.1 Cable connectors.- All cable connectors furnished with the equipment for the purpose of making external connections shall be clearly identified on the plug-in side by word labels descriptive of their specific function. Cable connectors shall be mechanically keyed to prevent incorrect installation and hookup. The mating connector part (connector or plug) that is electrically energized shall contain female contacts.

1-3.9.2 Ferrule-resistor positions.- All ferrule-resistor positions shall be marked to indicate the ohmic value of the resistor required for the particular position or mounting.

<u>1-3.9.3 Other ferrule-mounting parts</u>.- Where other parts with ferrule ends such as semiconductor rectifiers and vacuum capacitors are mounted in fuse clips, polarity marking shall be provided.

<u>1-3.9.4 Fuse positions</u>.- All fuse positions shall be marked with the rated current capacity of the fuse to be employed. Fuse positions for delayed-action fuses shall have the additional designation SLOW. The markings shall be on the insertion side, so as to be visible when replacing fuses.

<u>1-3.9.5 Terminal strips and blocks</u>.- The terminals of all terminal strips and blocks, including those which are used for movable links or other adjustable circuit jumpers, shall be identified by numerals or other designations located immediately adjacent to the respective terminals, and marked directly on the terminal strip or block or immediately adjacent thereto.

<u>1-3.9.6 Polarized parts</u>.- Where mounting arrangements for polarized parts are such that it would be possible for a replacement part to be mounted with terminal positions misplaced or reversed (as in the case of polarized capacitors, semiconductor diodes or transistors, microelectronics, relays, connectors, transformers), polarity markings shall be provided on the mounting structure of the equipment, located and oriented so that the symbols can be clearly associated with the physical location of the connection points. Devices in the listing below shall have the specific markings indicated.

(a) Semiconductor diodes: The schematic graphical symbol (as used on instruction book diagrams).

(b) Transistors and other semiconductor devices having three or more leads: The schematic graphical symbol shall be used wherever marking space permits; otherwise use identifying letters (such as EBC for transistors).

(c) Use polarized capacitors and other devices with + and - terminal markings.

<u>1-3.9.7 Wafer switches</u>.- Markings or other means of identification shall be provided on the equipment to enable a technician to identify the physical locations of wafer switch contacts for circuit tracing purposes.

<u>1-3.9.8 Marking controls and indicating devices</u>.- Markings shall be provided on the front of each exterior and interior panel and panel door, and also on control mounting surfaces of each chassis, subpanel, etc., to clearly designate the functions and operations of all controls, fuses,

and indicating devices mounted thereon, protruding through, or available through access holes therein. All markings shall be located on the panel or chassis in correct relationship to the respective designated items.

1-3.9.9 Other electrical parts.- On subminiaturized assemblies, transistors, integrated circuits, printed circuit boards, or other form of assembly where space is at a premium, the reference designation need not be marked. In lieu thereof, reference designation markings shall be shown by means of a pictorial diagram, line drawings, photographs or other descriptive means in the maintenance (or other appropriate) manuals to provide for circuit identification (by means of reference designations) appropriate for the equipment.

1-3.9.10 Non-electrical parts.- The reference designation for each non-electrical part, except screws, nuts, washers, bushings, pipe fittings and similar small hardware, shall be marked on the chassis, frame, panel, etc., immediately adjacent to the part; but if space is not available, the reference designation shall be marked on the part itself.

1-3.9.11 Panel markings.- The visible surface adjacent to panel facilities such as connectors, controls, indicators, jacks, keys, switches and fuse holders shall be marked with a suitable word, phrase, or abbreviation, indicating the use or purpose of the part. These markings shall be legible so that the function of the panel facility can be identified by the operator. Operating controls shall be provided with markings that permit the operator to set the control to a predetermined point. Markings on the fronts of panels and panel doors (other than equipment nameplates, 1-3.10) shall be made in accordance with one of the following subparagraphs.

1-3.9.11.1 Individual designation plates.- Where individual designation plates are used, one of the following types shall be employed (thicknesses shown are minimum acceptable values):

(a) 0.03-inch aluminum (overall water-dip lacquer on finished plate) or 0.03-inch nickel silver; reverse-etched, raised characters with dull metal finish; depressed background finished in black enamel.

(b) 0.02-inch photosensitive anodized aluminum, processed for white metal characters with jet black background; photosensitive silver compounds shall be imbedded within the oxide layer, and the image shall be sealed in the oxide layer by chemical treatment.

(c) 0.04-inch aluminum, baked finish or anodized finish, dull black, engraved through the finish.

(d) 0.04-inch laminated thermosetting plastic, dull black surface, beveled edges, engraved white characters (white-filled or engraved through to the laminated white plastic layer).

1-3.9.11.2 Markings on the panel surface.- One of the following processes shall be used:

(a) Engraving through the paint and then filling with contrasting-color enamel.

(b) Marking by epoxy-ink process.

(c) Marking on photo-sensitive anodized aluminum.

1-3.9.12 Interior marking methods.- Markings on the interior and rear surfaces of equipment shall be made by one of the following methods, using white markings on dark surfaces and black markings on light surfaces to provide maximum readability:

(a) Engraving through paint. On unpainted surfaces, contrasting-color or enamel shall be used as a filler of the engraving except where contrast without filler provides adequate readability.

(b) Silk screen process.

(c) Stenciling.

(d) Individual designation plates using any one of the above methods, or one of the methods described in paragraph 1-3.9.11.1.

1-3.9.13 Marking required on equipment.- The contractor shall mark the following on each piece of equipment having an FAA nameplate.

Date Inspected:
Date Installed:

1-3.9.13.1 Stamping of actual dates.- The FAA Quality and Reliability Officer (QRO) will stamp in the actual date the equipment is inspected, using a rubber date-stamp. If no FAA QRO is assigned, the contractor shall stamp in the date inspected (the date on which the equipment successfully passes the final factory tests as shown in the certified test data). The date installed shall not be inserted.

1-3.9.13.2 Location of marking.- The marking and stamping shall be located on the back side of the front panel door unless the required space is not available, in which case the marking shall be located on the rear vertical surface of the chassis. If space is not available in either location, or where construction differs from that described above, the contractor shall obtain Government approval of the proposed location before marking the equipment.

1-3.10 Nameplates.- Each subsystem described by a separate Part in this specification (e.g., each sensor, DPU, DCP etc.) shall have a nameplate designed by the contractor and approved by the FAA. The nameplate shall include the part name, type (and any other identifying characteristics), serial number, and manufacturer's name and address. Before manufacturing the nameplate, the contractor shall submit his detailed manufacturing drawing of the nameplate to Federal Aviation Administration, Washington, D. C. 20590, Attention: Contracting Officer, for checking of entries and other requirements. The drawing shall be in complete detail showing all entries, except that the equipment type designation, if not known to the contractor, may be omitted. In such case, the type designation will be provided to the contractor when the checked drawing is returned to the contractor.

Serial numbers shall be assigned starting with 1 for each subsystem unit having an individual nameplate, and shall continue consecutively up to the total number of such equipment units on the contract.

1-4 QUALITY ASSURANCE PROVISIONS

1-4.1 Quality control program and plan.- The contractor shall establish and maintain a quality control system in accordance with FAA-STD-013 and the contractor's Quality Control System Plan (QCSP), which shall be incorporated into and made a part of the contract. The quality control system shall provide for controls and inspection and test of all items required by the contract in accordance with the contract terms, including, but not limited to, contract specifications, FAA-STD-013 and the QCSP. Unless otherwise specified, all tests and inspections to determine compliance with the specification shall be made by the contractor and shall be subject to Government surveillance and inspection.

1-4.1.1 Computer Software Quality Program Plan.- The contractor shall establish and maintain a quality control system in accordance with FAA-STD-018 and the Contractor's Computer Software Quality Program Plan (CSQPP). The quality control system shall provide for controls and for inspection and test of all items required by the contract, in accordance with the contract terms, including but not limited to contract specifications, FAA-STD-018 and the CSQPP.

1-4.2 Contractor's detailed test plan.- The contractor shall develop a detailed test plan which includes a list of the tests he proposes to conduct as a means of proving compliance with the performance requirements of this specification. The test plan shall identify all detailed tests to be performed and shall be submitted to the Government for formal review and approval. The plan shall include tests to demonstrate every requirement in this specification, by paragraph number, and whether the contractor shall prove compliance with that requirement through demonstration, inspection, analysis, or by subjecting it to qualification acceptance testing. The testing proposed by the contractor shall include the tests of paragraph 1-4.4, broken down into the classification of specification compliance tests (1-4.4.2), Independent Verification Tests (1-4.3.2.2), production tests (1-4.4.4), type tests (1-4.4.5) and final acceptance tests (1-4.4.6). Where specific tests are not defined in this specification, it is the contractor's responsibility to develop the necessary tests to prove compliance with this specification. The plan shall include, but is not limited to, the following information for each test:

(a) Organizational roles and responsibilities

(b) Step-by-step description of how the test is to be performed, including operating modes, and test schedule.

(c) System, subsystem or component configuration.

(d) Test procedure content and preparation

(e) Facilities/test equipment and data acquisition equipment required.

(f) Operating environment and cyclic conditions.

(g) Standard to be used for comparison.

(h) Criteria for test failure or success.

(i) Corrective action and required retest in the event of failure.

(j) Test result documentation.

(k) Milestone charts and schedules of tests

1-4.2.1 Test data forms and submission of test documentation.- The contractor shall prepare test data forms for each test procedure. Separate forms shall be prepared for each test classification. The title page for each set of test data forms shall show the item tested, serial number, specification number and date, and contract number and date. The individual test data form shall indicate, for each test, the applicable specification, paragraph number, and performance limits stated therein, and it shall provide for the recording of all observed data and all intermediate steps or mathematical calculations which may be involved in determination of the final measurement. All data shall be quantitative and each final entry shall be in units directly comparable to the specification limits. The completed test data forms shall be signed by the contractor's designated representative and shall be submitted to the assigned FAA QRO for verification. Submission for approval of the test plan, test procedures, and test data forms shall be as specified in the contract schedule.

1-4.2.2 Failures.- Failures occurring during the conduct of any test in the test program shall be reported, analyzed and corrected in accordance with the reliability failure reporting, analysis, corrective action (FRACAS) program (paragraph 1-3.5.3.4). The reliability and maintainability assessment shall be updated monthly to reflect the results of testing.

1-4.2.2.1 Reject and retest.- When any equipment is tested and fails to meet the requirements of this specification, Government acceptance shall be withheld until the cause of the failure is corrected. Correction of deficiencies observed during testing shall be the responsibility of and at the expense the contractor. After correction of discrepancies, all tests failed and all tests affected by redesign shall be repeated and successfully completed prior to Government acceptance.

1-4.2.2.2 Inspection after each test.- At the completion of those tests which could degrade the physical characteristics (i.e., exposure to humidity, salt fog, temperature, etc.), the equipment shall be inspected for rust, corrosion, flaking of plating, deterioration, and deformation of plastic materials, to assure specification compliance.

1-4.3 Validation and demonstration of quality requirements.- The procedure to be followed by the contractor in validating and demonstrating that the AWOS system meets the requirements of this specification consists of three phases:

Phase I - Design verification
Phase II - Preproduction
Phase III - Production

1-4.3.1 Phase I. Design verification.- The contractor shall verify, through a series of design verification reviews in accordance with MIL-STD-1521, that his overall system design is in compliance with the performance and reliability requirements of this specification. These design reviews shall include all requirements of the AWOS system (hardware, software, interfaces, installation, etc.) and shall reference every requirement of this specification in demonstrating compliance.

<u>1-4.3.1.1 Reliability modeling</u>.- A reliability mathematical model based on system/subsystem functions shall be developed and maintained throughout the contract in accordance with paragraph 1-3.5.3.1.2 and MIL-STD-785, Task 201.

The reliability model shall be updated monthly in Phase II and quarterly in Phase III with information resulting from reliability and other relevant tests as well as changes in configuration and operational constraints. Inputs and outputs of the system reliability mathematical model shall be compatible with the input and output requirements of the subsystem level analysis models.

<u>1-4.3.1.2 Reliability prediction</u>.- Reliability predictions (MIL-STD 785, Task 203) shall be made for the system and the subsystems. Both logistics and mission reliabilities shall be predicted. Predictions shall be based on the reliability model, and shall be made showing basic reliability (MTBF) of the AWOS system during the life specified by the Government to provide a basis for maintenance and logistics support analysis. These predictions shall be made using the associated reliability block diagram and failure rate data in MIL-HDBK 217 under a ground fixed (GF) environment and 40°C ambient temperature. (Other failure rate data or sources require Government approval). Items shall not be excluded from the reliability predictions unless substantiating documentation verifies that the item failure has no influence on the required measure of reliability. Prior to such an exclusion from the predictions, an assessment shall be made and approval obtained from the Government.

<u>1-4.3.1.3 Design verification reviews</u>.- The contract will specify at least two design verification reviews: a preliminary design review and a final design review. These reviews will give the contractor the opportunity to provide the results of his reliability prediction to the Government, as well as a design review of the entire system. During the preliminary design review (or any intermediate design verification reviews as may be specified by the Government), the contractor shall use the results of the reliability prediction process to: (1) identify those critical areas requiring redesign; and (2) aid in the selection of the option that will satisfy the functional, accuracy, reliability and other requirements of this specification. During the final design review, reliability predictions based upon the reliability model shall reflect compliance with the design of the entire system.

<u>1-4.3.2 Phase II. Preproduction phase</u>.- Upon satisfactory completion of the final design verification review, the Government will authorize the contractor build five (5) systems in accordance with the approved final design. These systems shall be produced and assembled using the sensors, subsystems, components, tools, jigs, fixtures, procedures and methods,

identical in all respects to the units that will be produced to satisfy the major production contract (Phase III). These systems shall be subject to the following tests:

1-4.3.2.1 Specification compliance (design qualification) testing.- Four systems (three for factory testing and one for compliance demonstration of installation techniques and documentation) shall be tested by the contractor in accordance with the approved test plan (paragraph 1-4.2) to demonstrate compliance with the requirements of this specification. Specific test requirements are outlined in paragraph 1-4.4.2.

1-4.3.2.2 Independent verification testing.- The remaining system shall be installed at a location designated by the Government, and will be operated by the Government (or its representative) for independent test and evaluation (paragraph 1-4.4.3). The AWOS contractor's test plan shall recommend a series of tests to be accomplished. It is intended that the Government will employ an independent contractor for this series of tests, which will be designed to verify compliance with the requirements of this specification, to identify and resolve reliability problems, as well as to intentionally look for failures and unsatisfactory operation under accelerated stress screening conditions. These tests will provide engineering information on failure modes and mechanisms of the total AWOS, its subsystems, sensors and components. Failures shall be analyzed, the cause of the failure defined, and corrective action shall be recommended. The purpose of these tests shall be to verify the factory test results and to generate failure statistics which shall be input to the reliability model (paragraph 1-4.3.1.1).

1-4.3.3 Phase III. Production phase.- After satisfactory completion of the testing required in Phase II, the Government will authorize production. During production, production (paragraph 1-4.4.4) and type (paragraph 1.4.4.5) tests shall be performed in accordance with this specification.

1-4.4 System testing.- Six classes of tests are required to complete the validation and demonstration of specification requirements as follows (Tests may be waived by the Government where previous test data and/or analyses are shown to be adequate).

(a) Contractor's Preliminary Tests (1-4.4.1)
(b) Specification Compliance Tests (1-4.4.2)
(c) Independent Verification Tests (1-4.4.3)
(d) Production Tests (1-4.4.4)
(e) Type Tests (1-4.4.5)
(f) Final Acceptance Tests (1-4.4.6)

1-4.4.1 Contractor's preliminary tests.- Prior to the time the contractor notifies the Government that the five preproduction systems are ready for inspection, and to demonstrate readiness for inspection, he shall make one complete set of the specification compliance tests required by this specification. These contractor-conducted preliminary tests will not qualify as formally approved design qualification tests, type tests, or production tests required by this specification.

1-4.4.1.1 Preliminary test data.- The contractor shall submit to the Government contracting officer a certified copy of the test data covering all the contractor's preliminary tests. This test data shall be submitted in accordance with the contract schedule in advance of the date set for inspection pursuant to paragraph 1-4.4.1.2.

1-4.4.1.2 Notification of readiness for inspection.- After submission of the preliminary test data, the contractor shall notify the Government contracting officer in writing that he is ready for specification compliance testing. Such notification shall be given before the contractor desires testing to begin, in accordance with the contract schedule.

1-4.4.2 Specification compliance (design qualification) tests.- The contractor shall conduct these tests in accordance with the contractor-prepared, Government-approved test plan (paragraph 1-4.2). The tests shall be designed to demonstrate that the AWOS system meets every requirement of this specification either through inspection, analysis or actual qualitative or quantitative tests. The AWOS system will not be authorized for full production by the Government until these tests are successfully completed. The specification compliance tests are to be performed on the AWOS preproduction systems and are categorically listed below.

- (a) Production tests
- (b) Functional and accuracy tests
  - (1) Sensor tests
  - (2) DPU tests
- (c) Environmental tests
- (d) Power and electromagnetic and lightning protection testing
- (e) Verification of operational performance
- (f) Maintainability demonstration
- (g) Central repair facility maintenance demonstration
- (h) Remote Maintenance Monitoring (RMM) Demonstration

1-4.4.2.1 Production tests.- Each AWOS system or component to be used in the specification compliance tests shall first pass the production tests (paragraph 1-4.4.4).

1-4.4.2.2 Functional and accuracy tests. - The contractor shall develop the necessary tests or documentation (subject to Government approval) to assure that all subsystems (DPU, sensors, display, voice and the operator terminal, etc.) comply with every requirement of this specification.

The contractor's test plan shall include, but is not limited to, the following sensor and DPU tests.

1-4.4.2.2.1 Sensor tests.- Each sensor shall be tested, or documentation shall be provided, to demonstrate compliance with the requirements and tests as described in Parts 2 through 9 of this specification, as well as all applicable sections of Part 1.

Tests performed on the Visibility (Part 7) and Cloud Height (Part 6) sensors by the Government prior to contract award may satisfy a portion of the requirements of this paragraph.

1-4.4.2.2.2 Data processing unit tests.- The DPU shall be subjected to qualifying tests as outlined in Part 12, paragraph 12-3, as well as applicable paragraphs in Part 1.

1-4.4.2.2.3 Other equipment tests.- Other AWOS subsystems shall be subjected to qualifying tests as outlined in appropriate testing subparagraphs in other parts of this specification.

1-4.4.2.3 Environmental tests.- The following test procedures are designed to provide the basis for a laboratory means of determining the environmental performance characteristics of the AWOS. The contractor's test plan shall contain the tests necessary to demonstrate satisfactory operation of the AWOS in accordance with this specification under the following conditions:

1-4.4.2.3.1 Low operating temperature test.- The AWOS system shall be subjected to the test conditions of RTCA DO-160 paragraph 4.5.1, at the low operating temperatures specified in paragraph 1-3.2.2.2 of this specification.

1-4.4.2.3.2 High operating temperature test.- The AWOS system shall be subjected to the test conditions of RTCA DO-160, paragraph 4.5.3, at the high operating temperatures specified in paragraph 1-3.2.2.2 of this specification.

1-4.4.2.3.3 Survival temperature test.- Successful completion of the tests specified in paragraph 1-4.4.4.2.4 (Burn in, with temperature cycling and random vibration) shall satisfy this requirement.

1-4.4.2.3.4 Altitude test.- The AWOS equipment shall be subjected to the test conditions of RTCA DO-160, paragraph 4.6.1, at the operating altitudes specified in paragraph 1-3.2.2.2 of this specification.

1-4.4.2.3.5 Humidity test.- The AWOS equipment shall be subjected to the test conditions of RTCA DO-160, paragraph 6.0, (equipment installed indoors: Category A; equipment installed outdoors: Category C).

<u>1-4.4.2.3.6 Blowing rain test</u>.- The AWOS equipment installed outdoors shall be subjected to the test conditions of MIL-STD-810, Method 506.2, Procedure I (blowing rain) under the conditions specified in 1-3.2.2.2(8).

<u>1-4.4.2.3.7 Sand and dust test</u>.- The AWOS equipment installed outdoors shall be subjected to the test conditions of RTCA DO-160, paragraph 12.0, Category D: equipment installed outdoors.

<u>1-4.4.2.3.8 Fungus resistance tests</u>.- The AWOS equipment shall be subjected to the test conditions of RTCA DO-160, paragraph 13.0 Category F.

<u>1-4.4.2.3.9 Salt fog test</u>.- The AWOS equipment installed outdoors (except for the Dewcell Dewpoint sensor, if appropriate) shall be subjected to the test conditions in MIL-STD-810, Method 509.2, Procedure I.

<u>1-4.4.2.4 Power, electromagnetic and lightning protection testing</u>.- The total AWOS system, including sensors, DPU, and peripheral equipment shall be subjected to power, electromagnetic, and lightning protection testing using a contractor-developed, Government-approved procedure.

<u>1-4.4.2.4.1 DPU power interruption tests</u>.- Power shall be disconnected from the DPU for a period of at least 4 hours at ambient (40°F, ±10°F) air temperature. The battery charger/power supply unit shall provide the DPU with power to maintain the RAM memory for a period of 4 hours. The real time clock shall continue to operate normally. After reapplication of power, the system shall return to normal operation (paragraph 1-3.2.2.1).

<u>1-4.4.2.4.2 Power input tests</u>.- The AWOS equipment shall be subjected to the test conditions of RTCA DO-160, category E, paragraph 16.5 (except 16.5.2.5 and 16.5.3). The following voltage and frequency definitions shall be used in lieu of those specified in RTCA DO-160:

Maximum: 132 volts RMS
63 Hz

Nominal: 120 volts RMS
60 Hz

Minimum: 108 volts RMS
57 Hz

<u>1-4.4.2.4.3 Lightning protection tests</u>.- The AWOS shall comply with the applicable requirements of this specification after the application of 400 volt spikes to all signal, control and power lines routed external to the AWOS equipment or facility. (Examples of such lines are sensor to

DCP data lines, DCP-DPU data lines, DPU to external subsystems, and all power lines). The test method shall be as specified for Air Force equipment in MIL-STD-462.

1-4.4.2.4.4 EMI tests.- The AWOS shall be subjected to the test methodology in MIL-STD-462 (Air Force equipment) to determine compliance with the EMI requirements in paragraph 1-3.3.3.6.

1-4.4.2.5 Verification of operational performance and system interface requirements.- The AWOS system shall be subjected to testing to confirm that its operational inputs and outputs and operator/user interfaces comply with the requirements of this specification, and that these outputs satisfactorily interface with other FAA systems (Part 19). After verification of interface requirements, the contractor shall perform a series of tests to verify sensor calibration and to validate the overall operational performance of each system.

1-4.4.2.6. Maintainability demonstration.- A maintainability demonstration shall be conducted on one system to verify that the objectives of the maintainability program (paragraph 1-3.5.4) have been met.

The contractor shall conduct the maintainability demonstration in accordance with the approved maintainability demonstration plan. The test plan shall be designed in accordance with MIL-STD-471 such that the probability of the Government accepting equipment that does not meet the Mean Time to Repair MTTR and Mean Periodic Maintenance Time (MPMT) requirements does not exceed 0.1. The contractor shall design the test so that fault simulation for corrective maintenance tasks shall be performed by the introduction of faulty parts and deliberate misalignment (bugging/etc.) as specified in MIL-STD-471. Samples are required for developing time-to-repair data. The contractor shall prepare a list of at least 200 faults, which may be augumented by the FAA. At least 100 faults shall be selected by the FAA and shall be randomly inserted into each component of the system. Corrective maintenance times shall be recorded. The FAA and the contractor shall select the technicians to perform the maintenance demonstration. The technicians shall have been given maintenance indoctrination in accordance with the contractor provided training.

Corrective repair times for each maintenance task shall consist of:

(a) Time to diagnose and verify a failure

(b) Time to locate the fault

(c) Time to isolate to a removable or adjustable component, module, etc.

(d) Time to remove/replace

(e) Time to make adjustments

(f) Time to verify correct operation

The total corrective repair time to complete each task shall be measured and the arithmetical mean of the times shall be calculated. The MTTR shall meet the requirements of paragraph 1-3.5.2.

In addition, each periodic maintenance task shall be performed on the system to demonstrate compliance with the requirement in paragraph 1-3.5.2.2. Periodic maintenance will not be charged against MTTR.

1-4.4.2.7 Off-equipment, off-site and depot level maintenance demonstration.- The contractor shall demonstrate to the FAA the adequacy of maintenance manual instructions for all off-equipment off-site and depot level maintenance actions.

1-4.4.2.8 Remote Maintenance Monitoring (RMM) Demonstration.- The contractor shall demonstrate that the AWOS complies with RMM requirements of this specification. As a minimum, this demonstration will:

(a) Show that the RMM test points developed indicate correctly the functions of the system elements feeding the test point

(b) Demonstrate that the RMM as connected can fault isolate to the LRU level with a 95 percent confidence factor

(c) Show that the AWOS allows the RMM to diagnose faults with the 95 percent confidence factor specified

(d) Demonstrate the capability of RMM to reconfigure AWOS remotely (reference para. 19-2.2.2)

1-4.4.3 Independent verification testing.- The preproduction system not used for specification compliance testing shall be provided to an independent testing contractor. See paragraph 1-4.3.2.2.

1-4.4.4 Production testing.- These tests shall be performed on every AWOS system produced by the contractor. The contractor shall conduct a production test program in accordance with the contractor-prepared,

Government-approved test plan (paragraph 1-4.2). These test results will be documented and available to the Government for review and shall include as a minimum:

(a) Data collected
(b) Analysis of the data
(c) Results of the test
(d) Assessment of production quality

1-4.4.4.1 Production screening.- Production screening and burn-in tests shall be performed on all boards, modules and subsystems with active components such as chips prior to final assembly to detect and reject reliability defects. The production screening tests shall incorporate non-destructive stress tests (e.g., temperature extremes) that are designed to accelerate potential latent failures.

1-4.4.4.2 Production acceptance tests.- Production acceptance tests shall be performed on each production AWOS system. These tests shall be based on predetermined critical parameters (as defined in the FAA-approved Test Plan) to verify that their operational characteristics conform to this specification. Production acceptance testing shall include, but not be limited to, the following tests:

(a) Visual Inspection
(b) Electrical Performance
(c) Burn-in, with temperature cycling and random vibration testing.
(d) Mechanical Performance
(e) System Calibration

1-4.4.4.2.1 Visual inspection.- Each system shall be given a thorough visual inspection to determine that the quality of material, construction and workmanship are in compliance with requirements. Particular attention shall be given to:

(a) Completeness
(b) Nameplates, markings and labels
(c) Component fit
(d) Finishes
(e) Welds
(f) Solder joints
(g) Lubrication
(h) Corrosion prevention
(i) Grounding
(j) Conformity to standard parts
(k) Other visible defects
(l) Workmanship (Requirement 9, MIL-STD-454)
(m) Uniformity (identical parts)

1-4.4.4.2.2 Electrical performance tests.- Each assembly such as DCP, DPU, or sensors shall be given a thorough electrical performance test to determine that all circuits are inherently sound, and that performance of the equipment is in compliance with the requirements of this specification. The tests shall include, but are not necessarily limited to: proper functioning of all lamps, switches, displays, controls, circuit breakers; proper voltages and signal forms at test points; proper operation of built-in test capability.

1-4.4.4.2.3 Mechanical performance tests.- Each subsystem shall be given a thorough mechanical test to insure compliance with the mechanical requirements of this specification. This test shall include, but not be limited to: trials to demonstrate the function and completeness of operating parts, blowers, connectors, and controls.

1-4.4.4.2.4 Burn-in, with temperature cycling and random vibration testing.- Each production system shall be subjected to a 48-hour burn-in period with normal power applied. After this initial burn-in has been completed, the total system shall undergo comprehensive temperature cycling and random single axis vibration testing as described in NAVMAT P-9492. These test shall be performed on the entire AWOS system (i.e., on components to be installed either in an indoor or an outdoor environment). The test may be performed on the entire system as an entity; or, subsystems may be tested individually or in groups, if constrained by the capability (i.e., size) of the test equipment. An outline of these tests follows:

Before the temperature cycling tests are performed, the AWOS system (except for a tipping bucket sensor, if appropriate) shall be subject to random, single axis vibrations for a period of at least 10 minutes. The frequency spectrum and power spectral density characteristics of this vibration shall be as described in Figure 5, NAVMAT P-9492. Normal power shall be applied during the vibration test. The AWOS system shall be checked for satisfactory performance after completion of the vibration test, and any failures shall be recorded, analyzed and corrected in accordance with paragraph 1-4.2.2 of this specification.

After successful completion of the vibration testing, the system shall be installed in a chamber suitable for conducting the temperature cycling test. The chamber temperature shall be increased from ambient to +140°F at a rate of 9°F per minute minimum. The AWOS equipment temperature shall be held stable at +140°F (±4°F) for a period of approximately 30 minutes. The chamber temperature shall then be reduced to -60°F (±4°F) at a rate of 9°F per minute minimum. The AWOS equipment shall be held at this temperature for a period of approximately 30 minutes. The chamber temperature shall then be increased (9°F per minute minimum) to a temperature of +140°F, and the cycle shall be repeated. Note that the temperature of the AWOS equipment will lag the chamber temperature; timing of 30 minutes at the hot and cold temperatures shall not begin until the internal components of the AWOS equipment (e.g., PC boards, etc.) have stabilized. The length of the cycle shall be adjusted to approximately 4 hours, with approximately equal (two hour) periods at the heating/hot and cooling/cold temperatures. Each AWOS system will be exposed to a minimum of 12 temperature cycles (a minimum of 48 hours) of testing.

During each temperature cycle, the input power to the AWOS shall be off from the start of the cooling period until the equipment has stabilized at the low temperature. AWOS power will then be turned on, and will remain on through the rest of the low temperature period, while temperature is being increased, and while the chamber and equipment is at the hot temperature. AWOS input power shall be turned off just prior to the start of the cool-down of the chamber.

At least one-half of the power-on periods (i.e., six of the twelve temperature cycles) shall be conducted with the input voltage to the AWOS at 10 percent above design voltage (i.e., 132 volts for a design voltage of 120 volts).

When power is applied to the AWOS system, appropriate testing shall be performed (as described in the Test Plan) to ascertain that the system is operating properly. When equipment temperatures are outside the normal operating temperature envelope in paragraph 1-3.2.2.2, it is recognized that the system operation may not maintain the accuracy tolerances in this specification.

In the event of a failure of any subsystem of the AWOS system, corrective repair shall be accomplished. This test shall not be satisfactorily passed until a minimum of 12 temperature cycles (at least 48 hours of testing) have been completed . The last two temperature cycles must be power-on (as described above) and failure free. Failures shall be recorded and analyzed in accordance with paragraph 1-4.2.2 of this specification.

<u>1-4.4.4.2.5 System calibration test</u>.- The contractor shall include a procedure within his test plan that will result in factory calibration of the system. This calibration procedure shall result in the determination that all elements of the system are functioning properly, and will also minimize the calibration necessary after installation in the field.

<u>1-4.4.5 Type tests and type test equipment selection</u>. - Type tests are tests performed to verify that the production systems continue to perform in accordance with this specification. Type tests shall be included in the test plan. These tests shall be performed on regular production systems, after completion of production acceptance testing (paragraph 1-4.4.4) on systems selected in accordance with this paragraph. As a minimum, type tests shall be those outlined in paragraph 1-4.4.2.2. The equipment selection for type testing shall be in accordance with the contract schedule. In the absence of specific requirements in the contract schedule, the following applies:

(a) The systems produced under the contract shall be assigned sequential numbers in order of reaching the stage of completion and readiness for testing. Using these sequential numbers, the equipment shall be divided into groups for type testing as shown in Table 1-II. One type test shall be performed for each type test group. Selection of a system for type test within the group shall be made by the FAA representative.

(b) If a type test is not successfully completed and requires parts or design changes or both in order to meet the specified type test parameters:

TABLE 1-II

TYPE TEST EQUIPMENT SELECTION

Type-Test Groups

Contract Quantity	I	II	III	IV	V	VI	VII	VIII
1-10	1							
11-25	1	2-10						
26-50	1	2-10	11-35					
51-75	1	2-10	11-35	36-60				
76-100	1	2-10	11-35	36-75				
101-150	1	2-10	11-50	51-100				
151-200	1	2-10	11-50	51-100	101-150			
201-300	1	2-10	11-50	51-100	101-150	151-200		
301-500	1	2-10	11-50	51-100	101-200	201-300	301-400	
501-700**	1	2-10	11-50	51-100	101-200	201-300	301-400	401-600

**701 and up as specified in the procurement document.

(1) Those parts or design changes, or both, shall be incorporated in the group from which the type test system was taken, and all systems of the group shall be retested to the extent determined necessary by the Government.

(2) The contractor shall propose a plan, acceptable to the Government, for the correction/modification of previously accepted and delivered systems in accordance with the contract. Where field modification is appropriate (whether by contractor or Government personnel) the contractor shall provide the necessary parts, instructions, and instruction manual revisions in accordance with FAA Order 1320.33 "Equipment Modification and Facility Instruction Directives."

1-4.4.6 Final acceptance tests.- After installation and calibration, a Joint Acceptance Inspection (JAI) and an acceptance stability run shall be performed on each AWOS system as specified in the contract. In addition, the provisions of the contract that specify site clean-up and provisioning of spare parts must be satisfied before final acceptance of each AWOS system by the Government.

1-4.5 Test equipment.- Contractor provided measuring and test equipment required for installation or on-site maintenance shall conform to all system test requirements described in paragraph 1-4.

1-4.6 Availability of applicable documents.- The contractor shall make available for reference use by the FAA QRO a complete set of the applicable documents (specifications, publications, drawings, except those issued by FAA) for the equipment being furnished on the contract.

1-4.7 Inspection of design and production status.- Upon request from the Government, the contractor (and his subcontractors) shall make available for review at his plant, at any stage of the contract, all information regarding the design and production status of the equipment being manufactured under the contract. Such information shall be available at the plant regardless of the point of manufacture of the individual components. The contractor shall provide, for retention by the Government, two copies of each schematic and logic diagram on all electronic assemblies. The schematics shall be those in effect at the time the request is made and all subsequent revisions shall be provided.

1-5 PREPARATION FOR DELIVERY

1-5.1 General preparation requirements.- The provisions of this paragraph apply only to spare parts and other items whose final acceptance by the Government is accomplished at the Contractor's facility.

1-5.2 Level of protection.- The preservation shall afford adequate protection against corrosion, deterioration, and physical damage during shipment from supply source to the first receiving activity, where the item may be subject to immediate use or controlled humidity storage.

The packing shall afford protection against damage during direct domestic shipment from the supply source to the first receiving activity for immediate use. This, in general, will conform to applicable carrier rules and regulations, and may be the supplier's commercial practice when such meets the requirements of this level.

1-5.2.1 Blocking and bracing.- Unless otherwise secured, items which do not completely fill the container shall be blocked and braced to prevent movement inside the container. Items having projecting parts which are subject to damage or which would tend to damage the barrier media shall be rigidly supported. Blocking or bracing shall be applied against areas of the items that are of sufficient strength and rigidity to resist damage. Distribution of supports to several points or to a large area of the item shall be provided. Ends of wood blocks or braces shall not be fastened to a wood container by end-grain nailing, toe nailing, or similar methods; they shall be fastened to sturdy parts of the container, or held in grooves formed by parallel cleats or securely socketed.

1-5.2.2 Cushioning.- Cushioning materials (or devices) shall be used to protect the contents and the preservation and packaging components from physical damage. The cushioning medium shall be placed as close to the items as practicable to prevent flexible barrier rupture or to ensure against free movement in rigid containers.

1-5.2.3 Bolting.- Items, such as subassemblies, having bolt holes in part of the item which is sturdy enough to resist breakage when rough-handled, shall, if practical, be bolted to one face of the container. In instances involving nonprecision bolt holes, the diameter of the bolt shall be the nearest standard size consistent with the diameter of the hole. In instances involving precision bolt holes, precaution shall be taken to ensure precision fitting bolts of proper characteristics to prevent marring or elongation; lag screws or lag bolts shall not be used in either instance. Holes bored through containers or mounting bases shall be the same size as the diameter of the bolt used. When container bases are provided with skids, the bolts shall extend through the skids whenever practical, and the bolts countersunk in the outer surface of the skid.

Standard cut washers shall be used under nuts to contact with wood. To ensure that the nuts will not come loose in transit, they must be positively secured by upsetting or nicking the threads of the bolt beyond the nut; by applying asphaltum, paint, or lacquer on the threads; by use of lock nuts; or by use of cotter pins with nuts. Bolts and nuts without corrosion-resistant finish shall, prior to use, be completely covered with a corrosion-preventive compound. The compound shall be thoroughly set before the bolts are used.

1-5.2.4 Barrier material.- A sealed, water-vaporproof bag or equivalent shall provide a protective wrapping over all AWOS components.

1-5.3 Marking.- Marking shall be applied on the bag and on the container. Marking requirements, including materials, methods, and sizes of markings, shall be in accordance with MIL-STD-129.

1-5.4 Spare Parts

1-5.4.1 Preservation, Packaging, Packing and Marking of Spare Parts.- Unless otherwise stated in the contract or order, the preservation, packaging, packing and marking of spare parts shall be in accordance with MIL-E-17555. Preservation and packaging shall be level A and packing shall be Level C.

1-5.4.2 Packing List.- A packing list for each spares shipping container shall be provided in accordance with MIL-STD-129. Each line item in the shipping container shall be identified on the packing list with the following data, as a minimum: item name, manufacturer's part number, manufacturer's code, National Stock Number as provided, and the quantity therein.

1-5.4.3 Delivery.- Delivery shall be in accordance with the contract schedule unless delivery is not specified therein. If not specified in the contract schedule, delivery of spare parts shall be made in not more than two lots.

1-5.4.4 Delivery Point.- Unless otherwise specified in the contract or order, the initial spare parts delivered under this specification shall be shipped to:

FAA Aeronautical Center
P.O. Box 25082
6500 South MacArthur Blvd.
Oklahoma City, Oklahoma 73125

Attention: Receiving Dock, Mark For: Operating Stock

PART 2 - WIND SPEED AND WIND DIRECTION SENSORS

2-1 PURPOSE

This Part establishes the unique performance and test requirements for wind speed and wind direction sensor units for AWOS. The general requirements for AWOS contained in Part 1 form part of this specification.

2-2 REQUIREMENTS

2-2.1 General.- The wind speed and wind direction sensors shall respond to winds of 2 knots (threshold) to 100 knots and shall perform as indicated in the following paragraphs.

The direction sensor will initially be installed aligned to true north. After removing the sensor from its mounting for maintenance, sensor design shall enable the accurate restoration of directional alignment of the same sensor or a replacement sensor of the same make and model without the necessity of another alignment survey.

Wind directions reported or displayed locally (i.e., Controller Video Display, Operator Terminal, voice over telephone, voice over ground/air radio) shall be given in degrees magnetic. Wind directions disseminated over communications external to the AWOS (e.g., to the ADAS) shall be in accordance with the appropriate Interface Control Document (i.e., wind direction may be required with reference to both magnetic and true north).

2-2.2 Characteristics

2-2.2.1 Wind speed performance

(a) The wind speed sensor shall provide an accuracy of two knots or 10% Root Mean Square Error (RMSE), whichever is greater, with a maximum error of 15% at any speed.

(b) The resolution shall be at least one knot.

(c) Distance constant less than 30 feet.

(d) Threshold - 2 knots.

2-2.2.2 Wind direction performance.- The wind direction sensor shall be designed to provide the following measurements:

(a) Range - 0° to 360°
(b) Threshold - 2 knots

(c) Accuracy - Within 5° (RMSE), with a maximum error of 10° at any direction

(d) Resolution - To the nearest 5.6 degrees (6 bit (or better) encoder)

(e) Time constant less than two (2) seconds

2-2.3 Reliability and maintainability.- The AWOS system containing the wind speed and direction sensor units shall meet the system reliability and maintainability requirements as specified in Part 1.

2-2.4 Sensor monitoring.- The wind speed and wind direction sensor units shall provide outputs to the DCP for the remote maintenance monitoring of functions that would indicate a malfunction of this subsystem (paragraph 1-3.5.4.3.2).

2-3 Accuracy testing.- The contractor shall conduct tests on the wind speed and wind direction sensors in a calibrated wind tunnel. The wind speed sensor shall be compared against a calibrated pitot static tube or transfer reference standard traceable to the National Bureau of Standards. The following test methodology shall be used:

2-3.1 Wind speed

(a) Test under "no rain" conditions. The sensor shall be tested throughout the full range to 100 knots in a calibrated wind tunnel. Four full cycles (2-100 knots) shall be conducted in increments of 2 knots between 2 and 10 knots, and in increments of 10 knots between 10 and 100 knots. The sensor shall be accurate within the limits stated in paragraph 2-2.2.1.

(b) The distance constant is expressed as:

$$D = T \times W$$

where:

D = Distance constant (in feet).
T = Time, in seconds, for the sensor to reach 63% of the step function change in the speed.
W = Wind speed (feet per second) in the wind tunnel.

The distance constant will be determined from an average of 10 runs under "no-rain" conditions (5 runs each with the tunnel wind speed at 10 knots (16.89 ft/sec) and at 20 knots (33.78 ft/sec), with the sensor propeller speed at zero at time zero). The distance constant must be less than 30 feet for the sensor to pass this test. (If the sensor is of a type with no moving parts (i.e., no propeller), the contractor shall develop a test, for FAA approval, to demonstrate the distance constant).

2-3.2 Wind direction

(a) Test under "no rain" conditions. The accuracy of the sensor shall be checked at each 15-degree increment. The accuracy shall be checked in 1-degree increments between 350 and 010 degrees (a dead band of up to 5 degrees is permissable). Two tests shall be conducted, and the RMSE accuracy calculated. The sensor shall be accurate within the limits specified in paragraph 2-2.2.2.

(b) The time constant will be determined from an average of 10 runs under "no-rain" conditions (5 runs each with the tunnel speed at 10 knots and at 20 knots). The vane shall be displaced 10 degrees from the indicated wind direction and released. The time constant shall be less than 2 seconds to reach within 5 degrees of the indicated wind direction.

PART 3 - AMBIENT TEMPERATURE SENSOR

3-1 PURPOSE

This part establishes the performance and test requirements for an ambient temperature sensor unit for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification.

3-2 REQUIREMENTS

3-2.1 General.- The ambient temperature sensor shall be capable of reporting temperatures in the range of -60° to $+130^{\circ}$ F.

3-2.2 Characteristics

3-2.2.1 Performance

(a) The accuracy of the sensor shall be 1°F (RMSE) for the entire range of the sensor, with a maximum error of 2° F at any temperature.

(b) Resolution - The resolution shall not be greater than one degree fahrenheit.

(c) Time constant - Not greater than 2 minutes.

3-2.2.2 Ambient temperature sensor unit.- The sensor unit shall consist of a thermal shield, protective housing and aspirator, sensor, mounting bracket(s) and all electronic circuitry necessary to meet the requirements of this specification.

3-2.2.2.1 Thermal shield.- The sensor shall be thermally isolated to assure the accuracies in paragraph 3-2.2.1 under the environmental conditions in Part 1, 1-3.2.2.2(b). The thermal shield shall be designed to allow quick access to the sensor for maintenance, to assure meeting MTTR requirements.

3-2.2.2.2 Protective housing and aspirator.- Means shall be provided to assure a sufficient flow of air to the sensor to meet the accuracies in paragraph 3-2.2.1. The protective housing shall be designed to prevent contamination of the sensing element and a blockage of airflow by particulates, insects, ice, or snow. The filter shall also be designed to prevent erroneous temperature readings or sensor failure arising from excessive moisture (e.g., from precipitation).

3-2.3 Reserved

3-2.4 Reliability and maintainability.- The AWOS system containing the temperature sensor units shall meet the system reliability and maintainability requirements as specified in Part 1.

3-2.5 Sensor monitoring.- The sensor units shall provide outputs to the DCP for the remote maintenance monitoring of functions that would indicate a malfunction of this subsystem (paragraph 1-3.5.4.3.2).

3-3 Ambient air temperature sensor accuracy testing.- The contractor shall perform all tests on the temperature sensor unit with the sensor in the aspirated enclosure supplied with each sensor. Temperature accuracy shall be verified with a calibrated temperature sensor that is traceable to the National Bureau of Standards. The test methodology is as follows:

(a) The temperature sensor shall be exercised through the full range (-60° to $+130^{\circ}$F) of the device in 20° F increments. This 20° F change in chamber temperature must be accomplished within five minutes, and the sensor reading will be taken five minutes after the chamber temperature is stable.

(b) The test cycle in (a) shall be performed a total of eight times (or four times with each of two sensors) (two increasing temperature cycles and two decreasing temperature cycles without radiation heating; and two increasing temperature cycles and two decreasing temperature cycles with radiation on the aspirated enclosure of 1.6 gram-calories per square centimeter per minute). The accuracy of the sensor shall be within 1°F (RMSE) for each test cycle (a total of 11 data points for each cycle).

(c) Time constant - The sensor shall be placed in a chamber and stabilized at 85° F. The temperature shall be rapidly raised (within one minute) 5 degrees (to 90° F); the sensor shall indicate a change of at least 3.2° F (the 63% response point) within 2 minutes or less (the time constant). The same test shall be repeated, but with a 5 degree decrease in temperature (within one minute); the time constant shall be 2 minutes or less for the sensor to respond with a change of 3.2° F.

PART 4 - DEWPOINT SENSOR UNITS

4-1 PURPOSE

This Part establishes the unique performance and test requirements for a dewpoint sensor unit for AWOS. The general requirements for AWOS are contained in Part 1 and form a part of this specification.

4-2 REQUIREMENTS

4-2.1 General.- The dewpoint sensor shall be capable of reporting temperatures of the dewpoint in the range of -30° to $+90^{\circ}$ F. If the dewpoint sensor is a dewcell, it shall have the necessary precautions to prevent damage to the sensor from excessively wet conditions (e.g., from precipitation or a loss of power). The dewcell probe shall return to normal operation, without damage, within 30 minutes after the abnormal, excessively wet condition is alleviated, and within 30 minutes after restoration of power after an outage or shutdown of any duration.

4-2.2 Characteristics

4-2.2.1 Performance

(a) Accuracy - The RMSE accuracy of the sensor shall be as follows:

(1) 2° F dewpoint for dry bulb temperatures of $+30^{\circ}$ to $+90^{\circ}$ F (80% to 100% relative humidity), with a maximum error of 3° F at any dry bulb temperature.

(2) 3° F dewpoint for dry bulb temperatures of $+30^{\circ}$ to $+120^{\circ}$ F (15% to 75% relative humidity),* with a maximum error of 4° F at any dry bulb temperature

(3) 4° F dewpoint for dry bulb temperatures of -20° to $+20^{\circ}$ F (25% to 95% relative humidity)*, with a maximum error of 5° F at any dry bulb temperature

*The minimum dewpoint required is -30° F.

(b) Resolution - The resolution shall not be greater than one degree fahrenheit.

(c) Time Constant - less than 2 minutes.

4-2.2.2 Sensor unit.- The sensor unit shall consist of a thermal shield, protective housing and aspirator, sensors, mounting bracket(s) and all electronic circuitry necessary to meet the requirements of this specification.

4-2.2.2.1 Thermal shield.- The sensor shall be thermally isolated to assure the accuracies in paragraph 4-2.2.1 under the environmental conditions in Part 1, 1-3.2.2.2(b). The thermal shield shall be designed to allow quick access to the sensor for maintenance, in order that the MTTR requirements of this specification are met.

4-2.2.2.2 Protective housing and aspirator.- Means shall be provided to assure a sufficient flow of air to the sensor as required to meet the accuracies in paragraph 4-2.2.1. The protective housing shall be designed to prevent contamination of the sensing element and a blockage of airflow by particulates, insects, ice, or snow. The protective housing shall also be designed to prevent erroneous dew point readings or sensor failure from excessive moisture (e.g., from precipitation).

4-2.2.2.3 Combined temperature/dewpoint sensor housing.- A single thermal shield and aspirator unit may be designed to include both the dewpoint and temperature sensors.

4-2.3 Reliability and maintainability.- The AWOS system containing the dewpoint sensor unit shall meet the system reliability and maintainability requirements as specified in Part 1.

4-2.4 Sensor monitoring.- The sensor unit shall provide outputs to the DCP for the maintenance monitoring of functions that would indicate a malfunction of this subsystem.

4-3 Testing.- All tests on the dewpoint sensor shall be performed with the sensor in the aspirated enclosure supplied with each sensor. Temperature and dewpoint accuracy will be verified using calibrated reference instruments traceable to the National Bureau of Standards.

(a) The following data points must be demonstrated:

(1) With an error not to exceed 2°F (RMSE) dewpoint

30° F temperature; 80%, 90%, 100% relative humidity
60° F temperature; 80%, 90%, 100% relative humidity
90° F temperature; 80%, 90%, 100% relative humidity

(2) With an error not to exceed 3° F (RMSE) dewpoint

30° F temperature; 15%, 45%, 75% relative humidity
60° F temperature; 15%, 45%, 75% relative humidity
90° F temperature; 15%, 45%, 75% relative humidity
120° F temperature; 15%, 40% relative humidity

(3) With an error not to exceed $4^{\circ}F$ (RMSE) dewpoint
-20° F temperature; between 65% and 95% relative humidity
0° F temperature; 25%, 60%, 95% relative humidity
$+20^{\circ}$ F temperature; 25%, 60%, 95% relative humidity

(b) The accuracy (RMSE) will be computed for each set of data points (i.e., (a) (1) is one set of data points), and will be based on four test runs (two of increasing humidity and two of decreasing humidity without radiation heating. Two test runs may be performed on each of two sensors).

(c) At ambient temperature and 50 percent relative humidity, change the dewpoint $+5^{\circ}$ (within one minute), and then -5° F (within one minute). In each case, the time constant shall be less than 2 minutes to reach 63% (3.2° F) of the 5° F change in dewpoint.

(d) At ambient temperature and 90 percent relative humidity with the sensor operating normally, power will be disconnected from the sensor for a period of one hour. Power shall then be reapplied, and the sensor shall return to normal operation and accuracy within 30 minutes.

PART 5 - PRESSURE SENSOR UNITS

5-1 PURPOSE

This Part establishes the unique performance and test requirements for a pressure sensor unit for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification.

5-2 REQUIREMENTS

5.2.1 General.- Two pressure sensor units shall be provided for each AWOS system. The pressure sensors shall measure the station barometric pressure when installed at locations at an elevation between -100 and 10,000 feet mean sea level.

5-2.2 CHARACTERISTICS

5-2.2.1 Performance.- Each pressure sensor shall be designed to provide the following measurements:

(a) Altitude Ranges - High pressure shall be the Standard Atmospheric Pressure at -100 feet plus 1.5 inHg (30.065 + 1.5 = 31.565 inHg). Low pressure shall be the Standard Atmoshperic Pressure at +10,000 feet minus 3.0 inHg (20.58 - 3.00 = 17.58 inHg).

(b) Pressure Range - The sensor shall be capable of measuring a pressure range at any fixed location (station) of plus 1.5 to minus 3.0 inHg from the Standard Atmospheric Pressure at that station elevation. Pressure sensors shall have a provision for setting the sensor to the station elevation to the nearest foot over the range of -100 feet to +10,000 feet to meet the pressure range requirement.

(c) Accuracy - 0.01 inHg (root-mean-square error) at all altitudes from -100 feet to +10,000 feet MSL; Maximum error, 0.02 inHg at any one pressure.

(d) Resolution - shall not be greater than ±0.005 inHg.

(e) Differential accuracy - The sensor shall exhibit a maximum differential accuracy of 0.01 inHg or less between any two pressure measurements taken from the same sensor 3 hours apart. Ambient temperature over this 3-hour period shall not change more than $\pm 5^{\circ}$ F; ambient pressure shall not vary more than 0.1 inHg over the 3-hour period.

(f) Maximum drift with time - each sensor shall be stable and continuously accurate within 0.01 inHg (RMSE) for a period of not less than six months. The maximum error shall be 0.02 inHg.

<u>5-2.2.2 Design requirements</u>.- The pressure sensors shall have provisions for venting to the outside of the building where installed. The venting interface (such as a gill port) shall be supplied as part of the pressure sensor unit as specified in the contract. Pressure variations due to airflow over the venting interface shall be avoided. The venting interface shall be designed to avoid and damp pressure variations and oscillations due to "pumping" or "breathing" of the pressure sensor, venting, and porting equipment. Each sensor shall have an independent venting interface (from separate outside vents through dedicated piping) to the sensors. The venting system shall incorporate a dehydrator, if required, to protect the sensor from excessive moisture. Provision shall be made either at the sensor, DCP or DPU for onsite adjustments to compensate for minor sensor drift. This adjustment shall be protected from tampering by unauthorized personnel. The adjustment shall be through a hardware input with a range of ±0.05 inHg, in 0.005 inHg increments. An indication of the adjustment must be available to the maintenance data terminal. Diagnostic data shall include information on the sensor offset adjustments, in order to allow for maintenance planning.

<u>5-2.3 Reliability and maintainability</u>.- The AWOS system containing the pressure sensor units shall meet the system reliability and maintainability requirements as specified in Part 1.

<u>5-2.4 Sensor monitoring</u>.- The sensor unit shall provide outputs to the DCP for the remote maintenance monitoring of functions that would indicate a malfunction of this subsystem.

<u>5-3 Accuracy tests</u>.- The contractor shall test both pressure sensor units that are part of the AWOS system selected for design qualification tests. Both sensors must pass this test. Tests shall use a calibrated barometer with an accuracy of ±0.003 inHg that is traceable to the National Bureau of Standards as a standard. The test methodology is as follows:

(a) Test the pressure sensor through the full range of performance (normally 17.5 to 32.0 inHg) in 1 inHg increments of both increasing and decreasing pressure. Partial range (4.5 inHg) pressure sensors shall be tested by setting the sensor to a pressure altitude from zero to 10,000 feet in 500 foot increments. The sensor will be tested from minus 3.0 inHg to plus 1.5 inHg at 0.5 inHg increments at each pressure altitude.

(b) Allow sufficient time for the sensor to achieve steady state at each data point (not to exceed 5 minutes).

(c) The sensor should be tested at ambient (+85° F) and at the hot and cold extremes called for in the environmental specification (paragraph 1-3.2.2.2) for each pressure test point in (a). This constitutes one test cycle.

(d) Two test cycles shall be performed on each of the two pressure sensors.

(e) The accuracy of the pressure sensor shall be 0.01 inHg (RMSE) for each test cycle performed, with a maximum error of 0.02 inHg at any one pressure.

(f) Differential accuracy (change in accuracy) of the pressure sensor shall be tested at ambient temperature (85° F) as follows:

(1) Take 14 measurements of pressure on the pressure sensor under test and 14 measurements of pressure on the reference barometer. This time shall be called t=0.

(2) Repeat the 14 measurements on the pressure sensor under test and 14 measurements of pressure on the reference barometer after an elapsed time of 3 hours and with an ambient temperature change of less than 5° F, and an ambient pressure change of not more than 0.1 inHg. This time shall be called t=3.

(3) Compute the average reading of the reference barometer at t=0. Compute the average reading of the reference barometer at t=3. Determine the difference in the two averages. If the difference is not less than 0.1 inHg, repeat steps (1) and (2).

(4) Compute the 14 errors in reading between the sensor and reference barometer at t=0.

(5) Compute the 14 errors in reading between the sensor and reference barometer at t=3.

(6) Subtract the 14 t=0 errors from the 14 t=3 errors determined in steps (4) and (5). These differences are the changes in accuracy (the differential accuracy).

(7) Compute the average and standard deviation of the 14 changes in accuracy determined in step (6). The average differential accuracy shall be less than 0.010 inHg. The standard deviation shall be less than 0.003 inHg.

(g) The resolution shall not be greater than ± 0.005 inHg.

(h) Test for maximum drift over a six month period to assure compliance with paragraph 5-2.2.1(f).

PART 6 - CLOUD HEIGHT SENSOR

6-1 PURPOSE

This Part establishes the unique performance and test requirements for a cloud height sensor unit for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification.

6-2 REQUIREMENTS

6-2.1 General. - This Part is written to include the requirements that are applicable to a cloud height sensor with a design range of 5,500 up to 12,500 feet, with surface visibilities equal to or greater than 1/4 mile. Sensors shall comply with the requirements throughout their design range. Periodic maintenance, such as lens cleaning, shall not be required more frequently than once every 90 days to maintain overall performance under normal conditions.

6-2.2 Characteristics. - The sensor shall detect the height of atmospheric phenomena (i.e., clouds and obscuring phenomena aloft) or, in the event the phenomena are ground based (e.g., fog), provide an estimate of contact height (CH) or vertical visibility (VV). CH is defined as the vertical height at which visual reference with recognized lights or objects on the surface can be established sufficiently to permit visual determination of the ground plane and position. VV is defined in Federal Meteorological Handbook No. 1, Surface Observations. The sensor shall have the capability of discriminating between a negative response (i.e., no hit) resulting from no phenomena within the sensor's design range and a sensor error/fault. The sensor shall not indicate a response (i.e., hit) that is not the result of the detection of atmospheric phenomena.

(a) Range - The sensor shall measure cloud heights and the heights of obscuring phenomena aloft up to 5,500 feet (minimum acceptable range) or, as an option, up to 12,500 feet. The range of the CH or VV estimate shall be up to 3,000 feet.

(b) Accuracy - 100 feet surface to 5,500 feet; 500 feet 5,501 feet to 10,000 feet; 1,000 feet above 10,000 feet.

(c) Resolution - Not greater than: 50 feet surface to 5,500 feet; 250 feet 5,501 to 10,000 feet; 500 feet above 10,000 feet.

(d) Detection performance - The sensor shall perform within the limits specified in paragraphs 6-3.2.2 and 6-3.2.3.

(e) Sampling - The sensor shall provide an output at least once every 30 seconds. To extend sensor life, the sampling rate may be reduced to at least one sample every 3 minutes when no clouds, obscuring phenomena aloft, or CH/VV values (i.e., hits) are detected for the preceding 15 minutes.

(f) Eye safety (for laser cloud height sensors) - As specified in Part 1, paragraph 1-3.3.3.8.

(g) Interlock safety devices - As specified in Part 1, paragraph 1-3.3.3.8.

(h) Laser power stability - The sensor unit shall contain a self-check, self-adjusting feature that will maintain laser output power at the level necessary to sustain sensor detection and accuracy throughout the life of the laser diode. An RMMS signal shall be generated to reflect the amount of compensation being used to maintain operating limits, thereby advising of the need for maintenance action before failure of the sensor. When this adjustment can no longer provide the compensation to maintain the sensor within specified operational limits, sensor operation shall be terminated.

(i) Optics contamination - An air blower or other device shall be used to reduce the contamination of the lens cover. An RMMS signal shall be generated to indicate the amount of optics contamination, thereby indicating the need for optics cleaning during periods of abnormal atmospheric conditions.

6-2.3 Reliability and maintainability. - The AWOS system containing the cloud height sensor unit shall meet the system reliability and maintainability requirements as specified in Part 1.

6-2.4 Sensor monitoring. - The sensor shall provide outputs to the DCP for the remote maintenance monitoring of functions that would indicate a malfunction of this subsystem. It shall also monitor parameters that have the potential for gradual degradation and indicate when a marginal situation is occurring.

6-3 Accuracy and detection tests. - The sensor shall be tested as follows:

6-3.1 Accuracy test. - The signal shall be projected horizontally to a uniform diffuse target (whose reflectivity approximates a cloud) at known distances (100 foot increments 100 to 5,500 feet, 500 foot increments from 5,600 to 10,000 feet, and 1,000 foot increments beyond 10,000 feet). All range points shall be accurate to within the accuracies specified in paragraph 6-2.2(b). This test is conducted at full rated power output.

6-3.2 Detection capability tests

6-3.2.1 Simulated optics contamination test

(a) This test simulates optics contamination, etc. The unit shall be operated with the laser return signal level reduced by 5 db with an overcast ceiling (measured by a Rotating Beam Ceilometer (RBC)) between 3,000 and 5,500 feet. The cloud hit response relative to the RBC shall be at least 75 percent during a 2-hour sample. (Return laser signal level may be reduced by an adjustment of laser emission power, receiver gain, or through the use of appropriate optical filters).

(b) The unit shall be operated over a 90-day period without any routine (periodic) maintenance. Test (a) shall be repeated at full power at the end of this 90-day period.

6-3.2.2 Detection tests under uniform sky conditions. - The sensor shall be tested under the following conditions:

Group A. Visibility greater than 3 miles, with a minimum of 10 percent of the data sets in each subgroup collected with light precipitation (rain and snow) occurring, and a minimum of 10 percent with moderate precipitation (rain and snow) occurring.

Subgroup	Heights
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

Group B. Visibility equal to or less than 3 miles, but equal to or greater than 1 mile, with a minimum of 10 percent of the data sets in each subgroup collected with light precipitation (rain and snow) occurring, and a minimum of 10 percent with moderate precipitation (rain and snow) occurring.

Subgroup	Heights
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

Group C. Visibility equal to or greater than 1/4, but less than 1 mile, with a minimum of 10 percent of the data sets in each subgroup collected with light precipitation (rain and snow) occurring, and a minimum of 10 percent with moderate precipitation (rain and snow) occurring.

Subgroup	Heights
1	100-700
2	800-1500
3	1600-3000
4	3100-5500
5	5600-12500

Group D. Not more than 3/10 total sky coverage with the lowest cloud layer at 20,000 feet or above under the following visibility conditions, with a minimum of 80 percent of the data in each subgroup collected under daytime conditions.

Subgroup	Visibility (miles)
1	Equal to or greater than 1, but less than 3
2	Equal to or greater than 3, but less than 7
3	Equal to or greater than 7

6-3.2.2.1 Collection of test data

(a) A minimum of 25 data sets shall be collected for each subgroup in Groups A through C (i.e., a minimum of 125 data sets shall be collected under each group). However, if weather conditions at the test site make collection of at least 25 data sets in all subgroups impossible, as many data sets as possible shall be collected in the affected subgroups. Further, for test data to be accepted, a continuous test period shall be selected to allow for representative data collection. Also, it must be clear that all data collected during the test period were considered. Any data not used shall be explained. For example, if data collection in a subgroup is truncated after 25 data sets are obtained, this fact shall be documented.

One data set is defined as the second 10-minute period during which a uniform cloud or obscuration is detected by the RBC or determined by a qualified weather observer. In order to be classified as a uniform cloud or obscuration, the RBC must continuously measure or a qualified weather observer determine a cloud, obscuration aloft or vertical visibility height (for a 30-minute period) that does not vary from its mean height more than the variance (below) more than 5 percent of the time.

Mean Height (as determined by observer or as measured by RBC)	Variance (feet)
Equal to or less than 1000 ft.	200
Greater than 1000 ft., but equal to or less than 2000 ft.	300
Greater than 2000 ft., but equal to or less than 3000 ft.	400
Greater than 3000 ft., but equal to or less than 5000 ft.	500
Greater than 5000 ft, but equal to or less than 7000 ft.	600
Greater than 7000 ft., but equal to or less than 9000	700
Greater than 9000 ft., but equal to or less than 12500 ft.	800

(b) A minimum of 25 data sets shall be collected for each subgroup under Group D. One data set is defined as the second ten-minute of any consecutive 30-minute period during which the cloud/sky coverage/visibility conditions specified for Group D are met.

6-3.2.2.2 Test standards

(a) An FAA-approved cloud height indicator whose accuracy is traceable to a National Weather Service approved and calibrated RBC or observations taken by a qualified weather observer shall be the standard for determining heights and sky conditions.

(b) An FAA-approved visibility sensor whose accuracy is traceable to an FAA standard shall be the standard for determining visibilities.

(c) Liquid precipitation measurements shall be made using an FAA-approved 0.01 inch per tip tipping bucket precipitation gage. Light precipitation is defined as one, but not more than two bucket tips in a ten-minute period. Moderate precipitation is defined as more than two, but not more than five tips in a ten-minute period. Heavy precipitation is defined as more than five tips in a ten-minute period. The intensity of frozen precipitation shall be determined by a qualified weather observer.

6-3.2.2.3 Criteria for acceptance of the candidate sensor under uniform sky conditions

(a) Group A, B and C conditions - The mean cloud, obscuration aloft, or vertical visibility height as measured by the RBC or determined by a qualified weather observer shall be determined for each data set. The variance for each cloud, obscuration aloft, and CH/VV height (i.e., hit) detected by the candidate sensor in each data set shall be computed. Eighty-eight percent of the data sets within a subgroup (e.g., 22 out of 25 minimum) shall satisfy the following condition: 90 percent of the heights determined by the candidate sensor in each data set shall agree with the mean height measured by the RBC or determined by a qualified weather observer within the variance limits as shown below. Negative responses, i.e., no hits, by the candidate sensor shall be included as data points and considered to be outside the variance limits. Also, the no-hit percentage in each subgroup shall not exceed 5 percent.

Mean Height (as determined by observer or as measured by RBC)	Variance for cloud and obscuration aloft heights (feet)	Variance for CH/VV values (feet)
Equal to or less than 1000 ft.	200	400
Greater than 1000 ft., but equal to or less than 2000 ft.	300	600
Greater than 2000 ft., but equal to or less than 3000 ft.	400	800

Mean Height (as determined by observer or as measured by RBC)	Variance for cloud and obscuration aloft heights (feet)	Variance for CH/VV values (feet)
Greater than 3000 ft., but equal to or less than 5000 ft.	500	--
Greater than 5000 ft., but equal to or less than 7000 ft.	600	--
Greater than 7000 ft., but equal to or less than 9000 ft.	700	--
Greater than 9000 ft., but equal to or less than 12500 ft.	800	--

The candidate sensor must successfully demonstrate the above conditions for each subgroup to pass this test. Failure of any subgroup constitutes failure of the test.

(b) Group D conditions - Not more than one hit per data set in each subgroup. More than one hit per data set shall constitute failure of the test.

6-3.2.3 Detection test under ragged overcast or obscured sky conditions

(a) Heights (cloud/obscuration aloft or CH/VV) measured by the candidate sensor shall be compared with heights measured by the RBC or determined by a qualified weather observer during ragged overcast or obscured sky conditions. Valid data shall be that collected during overcast or obscured sky conditions below 12,500 feet as verified by an RBC hit percentage of 95 percent or more, or as determined by a qualified weather observer, during a 20-minute period. Negative responses, i.e., no hits, shall be included as data points and considered to be outside the variance limits. Calculate the percent of heights (i.e., hits) by the candidate sensor falling within the ranges in paragraph (b), below, under each of the conditions specified in paragraph (c), below, with allowable height variances as specified in paragraph 6-3.2.2.3(a). Data shall be collected under as many of the conditions as possible. Further, for test data to be accepted, a continuous test period shall be selected to allow for representative data collection. Also, it must be clear that all data collected during the test period were considered. Any data not used shall be explained.

(b) Height ranges (as determined by RBC or qualified observer)
(1) 100-700 feet
(2) 800-1500 feet
(3) 1600-3000 feet
(4) 3100-5500 feet
(5) 5600-12500 feet

(c) Conditions

(1) No precipitation. Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

(2) Light or moderate precipitation (rain and snow). Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

(3) Heavy precipitation (rain and snow). Visibilities 1/4 to 1 mile, 1 to 3 miles, and greater than 3 miles.

(d) A minimum of 90 percent weighted average of the hits by the candidate sensor shall fall within the range of the RBC or within the height range determined by a qualified weather observer. Also, the weighted negative response, (i.e., no hit), percentage shall not exceed 5 percent.

6-3.2.4 Snow and ice environmental test - The cloud height sensor window(s) shall demonstrate an ability:

(a) To remain clear of snow under the condition accumulating at a rate of 2 inches per hour for one hour at a temperature of 20°F.

(b) To remain clear of ice for 60 minutes under conditions of freezing rain equivalent to a buildup of one-half inch per hour radial thickness of clear ice.

PART 7 - VISIBILITY SENSOR

7-1 PURPOSE

This Part establishes the unique performance and test requirements for a visibility sensor and an ambient light sensor unit for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification.

7-2 REQUIREMENTS

7-2.1 General.- The visibility sensor shall be capable of measuring or obtaining the transmittance or scattering coefficient of the atmosphere, in order to report visibilities from less than one quarter mile to 10 miles. Methods of calibration traceable to an FAA transmissometer standard must be provided. Periodic maintenance, such as lens cleaning, shall not be required more frequently than once every 90 days to maintain sensor accuracy.

7-2.2 CHARACTERISTICS

7-2.2.1 Visibility sensor performance

(a) Resolution: In terms of equivalent visibility, the sensor shall provide data to the DPU to report visibility values as follows (in statute miles): Less than 1/4, 1/4, 1/2, 3/4, 1, 1-1/4, 1-1/2, 1-3/4, 2, 2-1/2, 3, 3-1/2, 4, 5, 7 and 10 miles.

(b) Accuracy: The sensor shall agree with the average of the transmissometer standards 80 percent of the time as follows:

Transmissometer standard (mi)	Sensor accuracy (mi)
1/4 through 1 1/4	± 1/4
1 1/2 through 1 3/4	+ 1/4, - 1/2
2 through 2 1/2	± 1/2
3 through 3 1/2	+ 1/2, -1
4 through 5	± 1

(c) Time Constant: The time for the sensor to reach 63 percent of the final output for a "step change" in visibility shall not exceed three minutes.

<u>7-2.2.2 Ambient light sensor</u>.- The visibility sensor shall contain an ambient light sensor (i.e., a photometer) to measure the ambient luminance within its field of view, and to generate a signal to the visibility sensor to indicate whether the ambient light level is day or night. It shall indicate day for increasing illumination between 0.5 and 3 foot candles (FC), and night for decreasing illumination between 3 and 0.5 FC. This sensor may be exposed to ambient light levels as high as 50 FC.

<u>7-2.3 Reliability and maintainability</u>.- The AWOS system containing the visibility sensor unit shall meet the system reliability and maintainability requirements as specified in Part 1.

<u>7-2.4 Sensor monitoring</u>.- The sensor unit shall provide outputs to the DCP for the remote maintenance monitoring of functions that would indicate a malfunction of this subsystem.

<u>7-3 Accuracy tests</u>.- The contractor shall test the visibility sensor using as a standard two transmissometers. The two installed reference transmissometers must agree with each other within ±10 percent of the extinction coefficient value computed from the transmittance measurements after correcting them for background error for a 10 minute period for each of the following tests. The visibility shall be determined by the transmissometer average.

(a) At least two months of accuracy test data shall be accumulated, assuring that a representative number of valid test points are experienced at each of the reporting increments (paragraph 7-2.2.1(a)) and under the conditions listed below (i.e., with, without precipitation). All data collected during the test shall be included in the test report. Any samples not included in determining the candidate sensor's accuracy shall be fully explained. The test data shall consist of a number of independent samples of ten minutes each, with at least five minutes between each sample. Samples shall consist of visibilities from less than 1/4 mile to greater than 10 miles, and shall be weighted in the following ratio:

70 percent without precipitation (e.g., in fog, haze or clear conditions).

30 percent with precipitation (i.e., 15 percent with rain, 15 percent with snow).

(b) Eighty percent of all sensor samples in each of the above categories (i.e., with, without precipitation) shall agree with the average of the transmissometer standards from less than 1/4 though five miles within the required accuracies stated in paragraph 7-2.2.1(b).

PART 8 - PRECIPITATION OCCURRENCE/ACCUMULATION SENSOR

8-1 PURPOSE

This Part establishes the unique performance and test requirements for a precipitation occurrence/accumulation sensor unit for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification.

8-2 REQUIREMENTS

8.2.1 General.- The term "precipitation" as used herein includes all forms, i.e., liquid, freezing, frozen or combinations thereof. The term "precipitation amount" is the liquid or liquid equivalent amount. The precipitation sensor shall provide an indication of precipitation occurrence and shall measure the precipitation amount. The sensor may, at the contractor's option, be designed as one unit, or precipitation occurrence and precipitation amount may be designed as separate units.

8-2.2 CHARACTERISTICS

8-2.2.1 Precipitation occurrence.- The sensor shall detect the occurrence of precipitation as specified below. It shall not "false alarm" on other moisture sources such as dew and frost.

8-2.2.1.1 Precipitation onset.- The sensor shall detect the onset of precipitation 95% of the time in each of the following cases:

a. With precipitation amounts of 0.11 inches per hour or more, the sensor shall detect the onset of precipitation within one minute.

b. With precipitation amounts of 0.05 to 0.10 inches per hour, the sensor shall detect the onset of precipitation within two minutes.

c. With precipitation amounts of 0.01 to 0.04 inches per hour, the sensor shall detect the onset of precipitation within five minutes.

d. With precipitation amounts of less than 0.01, but equal to or greater than 0.005 inches per hour, the onset of precipitation shall be detected within ten minutes.

<u>8-2.2.1.2 Precipitation cessation</u>.- The sensor shall detect the cessation of precipitation within five minutes 95% of the time.

<u>8-2.2.2 Precipitation (liquid equivalent) accumulation</u>.- The sensor shall be capable of measuring the liquid equivalent precipitation amount within a range of 0.01 to 5 inches per hour, with a resolution of 0.01 inches and an accuracy of 0.02 inches per hour (RMSE) or 10 percent (whichever is greater).

<u>8-2.3 Reliability and Maintainability</u>.- The AWOS system containing this sensor shall meet the system reliability and maintainability requirements as specified in Part 1.

<u>8-2.4 Sensor monitoring</u>.- The sensor shall provide outputs to the DCP for the remote maintenance monitoring of functions that would indicate a maintenance malfunction of this subsystem.

<u>8-3 Testing</u>.- The contractor shall include tests in the Test Plan (Part 1, paragraph 1-4.2) to demonstrate that the precipitation occurrence/accumulation sensor meets the requirements of this Part under the environmental conditions specified in Part 1.

PART 9 - PRECIPITATION TYPE SENSOR UNIT

9-1 PURPOSE

This part establishes the unique performance and test requirements for a precipitation type sensor unit for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification.

9-2 REQUIREMENTS

9-2.1 General - The term "precipitation type" as used herein includes the following: rain, drizzle, snow, ice pellets and hail. The precipitation type sensor shall provide an indication of the type of precipitation occurring, or shall output "precipitation" for any precipitation (liquid, freezing, frozen or combinations thereof) when a type is not identified. This sensor unit may, at the contractor's option, be designed as a separate unit or may be combined with the requirements of other parts of this specification (e.g., Part 8) so that one unit fulfills the requirements of two or more Parts.

9-2.2 CHARACTERISTICS

9-2.2.1 Precipitation Type Identification.- The sensor shall detect the precipitation type when the rate of precipitation equals or exceeds 0.01 inches per hour with the goals specified below:

(a) In the temperature range 28°F to 38°F:

(1) Identify rain as rain: 90% of the cases
(2) Identify drizzle as drizzle: 80% of the cases
(3) Identify snow as snow: 90% of the cases
(4) Identify ice pellets as ice pellets: 50% of the cases

(b) In temperatures less than 28°F: Identify snow as snow: 99.0% of the cases.

(c) In temperatures greater than 38°F:

(1) Identify rain as rain: 99.5% of the cases
(2) Identify drizzle as drizzle: 90% of the cases
(3) Identify hail as hail: 90% of the cases

Notes: 1. Detection of the onset and cessation of precipitation shall be as specified in Part 8.

2. Only one precipitation type shall be reported at any given time. The priority for reporting shall be: (1) hail, (2) ice pellets, (3) snow, (4) rain, (5) drizzle and (6) precipitation - no type identified.

<u>9-2.3 Reliability and Maintainability</u>.- The AWOS system containing this sensor shall meet the sensor reliability and maintainability requirements as specified in Part 1.

<u>9-2.4 Sensor monitoring</u>.- The sensor shall provide outputs to the DCP for the remote maintenance monitoring of functions that would indicate a maintenance malfunction of this subsystem.

<u>9-3 Testing</u>.- The contractor shall include tests in the Test Plan (Part 1, paragraph 1-4.2) to demonstrate that the precipitation type sensor unit meets the requirements of this Part under the environmental conditions specified in Part 1, paragraph 1-3.2.2.2.

PART 11 - DATA COLLECTION PACKAGE (DCP)

11-1 PURPOSE

This Part establishes the performance, design and test requirements for the Data Collection Packages used to acquire the analog and digital AWOS sensor output data, process (if appropriate), format and transmit the data to the AWOS Data Processing Unit. The DCP shall accept RMM input from the sensors, insert its own RMM signal, and pass the resulting information to the DPU. The DPU and DCP will communicate in half or full duplex. Two (2) DCPs may be necessary at some AWOS installations. The general requirements for AWOS contained in Part 1 form a part of this specification.

11-2 REQUIREMENTS

11-2.1 DCP description.- The DCP shall be capable of collecting data from an array of AWOS sensors (which output the data in either analog or digital form), combine the data, and format it into a serial stream for transmittal to the AWOS processor through either a single-pair, voice-grade land line (either direct or through a telephone switch), fiber optics or a radio link. The DCP, in conjunction with the DPU, shall use an error detection code to allow checks of the validity of sensor data (see Part 12, paragraph 12-2.2.1.2).

In addition, the DCP design includes: the sensor personality interface to standardize the sensor outputs; a complete remote maintenance monitoring (RMM) capability; EMI/RFI protection; and line transient and over-voltage protection with automatic reset.

The contractor shall be responsible for supplying a complete DCP to include the outdoor enclosure, connectors, mounting hardware and any other components required for a complete unit.

11-2.2 Characteristics

11-2.2.1 Performance.- The DCP shall perform the following functions:

(a) Sensor output standardization - The DCP shall sample sensor and sensor status signals, and shall convert the output from the sensors into digital format which preserves sensor resolution and accuracy. The conversion shall be performed by the sensor personality interface. Some sensors may contain the standardization circuits internally, thus obviating the need for a personality interface in the DCP. When required, the DCP shall have the capability to insert through digital hardware any necessary calibration adjustments to the raw sensor data.

(b) Capacity - Each DCP shall be capable of accepting the sensors required under this specification with an expansion capability to a total of 12 sensor inputs.

(c) Sampling Rate - The sensor sampling rate shall be controlled by the software developed to satisfy the algorithms in Part 12, Appendix 12-I.

(d) Data Formatting - The DCP shall combine the digitized analog and digital sensor output signals and other DCP data into a single serial data stream. The data format shall uniquely identify each data source.

(e) DCP Controller - Operation of the multiplexers, converters, data formatting and transmission shall be under control of a DCP controller. In case of a power failure, sensor/DCP or DCP/DPU communication failure or error, or any other disruption of sensor or DCP operation, upon alleviation of the disruption the DCP controller shall be automatically reinitialized to produce normal operations. When this situation occurs, an identifying signal shall be provided to the RMM data.

(f) RMM - The DCP, in conjuction with the DPU, shall monitor the operation of the circuits and other devices for proper operation, (e.g., AC and DC power sources, the DCP enclosure temperature, sensor operation, aspirator fans and transmission modes). These RMM signals shall be transmitted to and collected by the DPU for transmission over the RMM circuits (see Part 1, paragraph 1-3.5.4.3.2, Part 12, paragraph 12-2.4, and Part 19, paragraph 19-2.2).

(g) Power monitoring and power reset - The DCP shall constantly monitor AC and DC power associated with its operation. If any output power exceeds limits which could result in component damage, the source shall be either clamped or disconnected and an appropriate signal shall be sent to the RMM system data. When the power returns to normal, it shall be automatically reconnected.

(h) EMI/RFI Protection - The DCP design shall include EMI/RFI protection, and line transient suppression devices (with automatic reset) on all input and output communication lines and power lines. See Part 1, paragraphs 1-3.3.3.5 and 1-3.3.3.6.

(i) Data Transmission - The DCP shall transmit the data to the DPU using a data protocol which shall enable the receiving unit to detect transmission errors and retransmit, if required. Recurring errors in transmission shall be reported to the RMM system. Bit error rate shall not exceed 10^{-6}; the bit error rate shall be transmitted to the RMMS. Sensor data with transmission errors shall not be processed by the DPU. The DCP shall contain any required modems to transmit all the data to the DPU.

<u>11-2.2.2 Interface ports</u>.- Interface port requirements are described in Part 19, paragraph 19-2.1.

<u>11-2.2.2 Reliability and maintainability</u>.- The reliability/maintainability requirements for the DCP are as specified in Part 1.

<u>11-3 Testing</u>.- The DCP tests shall demonstrate that the unit meets the stated design requirments for the full range of environmental conditions by demonstrating, as a minimum, compliance with the following requirements:

(a) Proper scanning of all programmed channels at each selected channel sampling rate.

(b) A/D converter accuracy.

(c) Lack of channel interaction.

(d) Maintenance of output data format.

(e) Accurate output of all RMM quantities.

(f) Proper operation of transient arrestors, overvoltage protection circuits, and automatic reset.

(g) Automatic reinitialization after a failure.

(h) The data processing unit tests in paragraphs 12-3.1 (2) and (3) shall be performed to verify correct operation of the DCP. These tests may be performed in conjunction with the DPU test procedures.

(i) Maintenance data terminal (MDT) capability.

PART 12 - DATA PROCESSING UNIT (DPU)

12-1 PURPOSE

This Part establishes the unique performance and test requirements for the Data Processing Unit (DPU) for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification.

12-2 REQUIREMENTS

12-2.1 DPU description.- The four main functions of the DPU are data acceptance, data reduction, data processing and product dissemination (digital and voice). The DPU accepts data inputs, performs various data reduction functions, implements AWOS algorithms and prepares weather observation reports. Using an integral computer generated voice capability, the DPU shall have the capability to transmit a voice weather observation (appended with a manual input (analog) voice message): (a) to a ground-air radio, and (b) to users via an integral automatic telephone answering device. The DPU is also responsible for maintaining real time, archiving, system control, and maintenance diagnostic and reporting functions. The DPU includes the central processing units (CPUs), system software, a computer generated voice capability, necessary modems, RMM circuits, a power supply and a cabinet. The system software shall include the algorithms for data reduction, a system monitor program, diagnostics, and appropriate routines for execution of the various system functions.

Government-furnished algorithms are contained in Appendix 12-I. The AWOS shall be designed to permit the Government to modify or change the algorithms without major changes to the hardware or software/firmware.

12-2.2 Equipment characteristics

12-2.2.1 Functions.- The following paragraphs describe the functional characteristics of the DPU.

12-2.2.1.1 Data acceptance.- The DPU shall have the capability to receive meteorological as well as system diagnostics (RMM) information either directly from the sensors, or from the sensors via one or two DCPs. The DPU shall also have the capability to accept cloud-to-ground lightning flash data from the ADAS, and to process this data using the thunderstorm algorithm for output as part of the weather message. The DPU shall have provisions for RMM monitoring of all unassigned sensor positions.

12-2.2.1.2 Data reduction.- This function consists of the preprocessing of information prior to the actual algorithm processing. The contractor shall design quality control checks (RMMS data checks) into the AWOS data reduction software to ensure that the data received by the DPU are accurate and complete, and that the associated equipment is working properly. If data from any sensor is erroneous or missing (e.g. the sensor loses power, etc.), that parameter shall be reported "missing" in the weather observation, and an appropriate signal shall be sent to the RMM data. Quality control checks shall be made on sensor data prior to its being processed. Each AWOS sensor and DCP shall contain internal RMM checks on proper functioning (Part 1, paragraph 1-3.5.4.3.2). Sensor data shall not be accepted by the DPU unless its own checks and those of its associated DCP are passed. Where the acceptable criteria for any data reduction checks are not specified in this specification, the contractor shall propose criteria to be approved by the Government. Some examples of sensor checks follow:

(a) Reference or calibration point checks (e.g., reference voltage; aspirator airflow; sensor heater current, etc.) shall be used to periodically test as many sensor functions as are practicable to provide confidence of proper operation.

(b) Upper and lower limit checks can be set corresponding to the operating limits of a particular sensor, or by the real-world installation limits of the processing algorithms. These are the gross error checks that will prevent reporting clouds below ground level, negative wind speeds, etc.

(c) Rate-of-change limits provide a failure detection criteria. For example, the temperature sensor may have upper and lower limits of $+130^{o}F$ and $-60^{o}F$, but a rate-of-change limit might be set by determining the maximum acceptable change in temperature or signal characteristics over a given period of time. Any data limit anomaly shall be stored in maintenance history to indicate potential trends that a sensor or its communication line may be deteriorating.

(d) The sensors shall incorporate data checks which depend upon the history of the sensor output to uncover existing or potential system problems or failures. For example, the mean and standard deviation of a sensor measurement can be calculated every hour. Upper and lower standard deviation limits can be established. (If the wind speed sensor has a mean greater than 3 knots but a standard deviation less than 0.5 knot, its signal probably has malfunctioned). Likewise, the wind direction sensor is probably inoperative if the wind speed is above 5 knots and the standard deviation of the wind direction sensor is less than 1 degree. Other examples of data checks include consistently low wind speeds, unvarying wind speed or direction, lack of visibility of more than five miles for long periods, a consistent cloud layer or a lack of clouds for long periods, etc.

12-2.2.1.3 Data processing.- The DPU shall implement the sensor algorithms and shall prepare the processed data as a weather observation in a digital format. Manual (keyboard or analog voice) inputs received from the Operator Terminal (OT) shall be appended to the weather observation as described in Part 15.

12-2.2.1.3.1 Weather parameter algorithms.- The appropriate Government-supplied algorithm (Appendix 12-I) shall be used to generate the weather parameter product. Any proposed changes in the algorithms shall be submitted, along with justification, to the Government for approval.

12-2.2.1.3.2 Products.- Contractions used in the OT and CVD weather message displays shall be as required by FMH-1 (Surface Observations) and FAA-ORD-7340.1 (Contractions). Data transmitted to the ADAS shall be in accordance with the AWOS/ADAS ICD 10-001 (Draft).

The DPU shall generate the following scheduled weather observations on a periodic basis.

(a) Current weather observation - A periodically updated weather message that is generated each minute containing current weather information for all activated parameters observed by AWOS. Winds shall be updated to the OT and the CVD every five seconds. The time indicated for the observation shall be the time that the data are processed. Significant changes from the last observation shall be noted by tagging the observation with an alert character (Appendix 12-I, paragraph 1.2.9).

(b) Hourly weather observation - Scheduled observations that are generated each hour using the latest updated parameters.

12-2.2.1.4 Product dissemination.- The DPU shall output its various products via the interface ports described in Part 19, paragraph 19-2.1.1

12-2.2.1.4.1 Automatic dissemination.- The DPU output shall be routed automatically to those output ports that feed equipment with a receive-only capability.

12-2.2.1.4.2 Dissemination by inquiry.- The DPU shall respond (output) to appropriate input commands from the OT, maintenance data terminal, or RMMS equipment.

12-2.2.1.5 Archive data.- The DPU shall store archive data in a nonvolatile (protected) memory, and have it available on demand for the OT display and the MDT. Maintenance data shall also be available at the RMMS. Operational archive data shall be available for a specific date and time, or for a specific date and a block of times. Maintenance data shall be stored and retrieved through the RMMS interface in logical units. The data buffer shall retain the archived data and shall provide the capability for protected retrieval and verification of the stored data. Retrieved AWOS archived data shall be certifiable and suitable for use in legal proceedings by including the observational data date, time and BIT status. The response time from request to display of any archive data shall not exceed five seconds. If the archived data exceeds the storage capacity, the priority for storage shall be for the most recent operational data. The deleted data necessary to accommodate the overflow shall be the oldest maintenance data, as specified in paragraph 12-2.2.1.6.5. When this situation occurs, the appropriate RMMS alarm message shall be generated.

Operational archive data shall consist of the following:

- o AWOS observation output
  - Current weather observations
    - Each minute for the last 15 minutes
    - Every five minutes for the last hour
  - Hourly weather observations for the last 15 days
- o A history of any product augmentation (paragraph 12-2.2.1.6.3) performed on the above archived observations. This history shall include the AWOS automated observation, any manual changes (i.e., the revised observation), and the initials of the editor.
- o Incident archiving.- This function permits authorized personnel using an OT to archive observations after an aircraft incident. When this request is initiated, the five minute observations shall be archived for the hour before and after the request. The AWOS shall be capable of archiving 3 incidents and storing this data for 15 days. If an attempt is made to archive more than this capability allows, the system will alert the OT operator that the incident archive capability is saturated, and that the incident must be archived manually (e.g., handwritten).
- o Alert Archiving.-This function shall archive the weather observation at the time a weather alert is declared (alerts which are generated automatically by AWOS as described in Appendix 12-I, paragraph 1.2.9, or urgent alerts (i.e., tornado, funnel cloud, waterspout) which are initiated by the operator through the OT). The last 30 alert observations shall be retained.

Maintenance archive data are specified in paragraph 12-2.2.1.6.5.

12-2.2.1.6 System control.- The DPU software shall provide for the control of the AWOS system through use of a maintenance data terminal (Part 13) and an OT (Part 15). A menu of control options shall be available for presentation on the OT and the MDT. System control functions may be performed on-site or remotely via communications links. Passwords shall be used to limit on-site access to authorized users only. System control functions shall include:

12-2.2.1.6.1 Monitor current output.- Monitor the current output of the AWOS by displaying the weather sequence(s) on the display, and by broadcasting the AWOS (to include any analog voice appended to the AWOS synthesized voice observation message) voice over a speaker or headset.

12-2.2.1.6.2 Retrieval of data.- Retrieve historical weather observation data by displaying archive data (paragraph 12-2.2.1.5).

12-2.2.1.6.3 Product augmentation.- This function allows an authorized observer to augment any observation product. (A specific password shall control access to the editing function.) Edited products shall include the initials of the editor (initials will not be disseminated with any observation product but will be archived internally by the DPU, along with the modification and the automated data that was overridden). Manual entries of weather phenomena not automatically observed shall be placed in the comments section of the observation. In the case of a sensor failure or an incorrect AWOS output, an operator (OT) shall have the capability to replace the incorrect parameter value with a "missing" symbol and to manually enter a corrected value. The OT shall provide the means for an hourly acknowledgement of the manually-entered data verifying its validity to the users. An authorized observer shall have the capability to:

(a) Monitor the current observation, including any manually entered data.

(b) Augment any observation product.

(c) Add to the voice message. The OT shall have the capability to manually input a voice message (30 seconds maximum) to the end of the computer generated voice message.

12-2.2.1.6.4 System modification.- This function will allow an on-site (OT or MDT) or remote (RMMS) operator or technician to reconfigure the AWOS system using keyboard entries. It includes the capability to set the clock, or disable any sensor, and to reconfigure system components (e.g., to compensate for a sensor or communication failure).

12-2.2.1.6.5 Provide maintenance diagnostic data.- A variety of information is required to facilitate the identification of system problems and/or failures to a local or remote (RMMS) technician. The following maintenance data shall be archived and available at the OT, MDT, and RMMS:

(a) A configuration report shall give the descriptive code of all AWOS options (sensors, displays, communications channels, software (including product thresholds and software version identifier) and system constants). A prominent indication (e.g., blinking or reverse video) of any error, failure or non-standard condition shall be reflected on the video display. The configuration report shall include the constants in the EPROM.

(b) A hardware status report shall give the status (on/off, deactivated, failed) of all AWOS hardware installed. This report shall contain a prominent indication of any error, failure, or non-standard condition.

(c) A four day maintenance data record shall be maintained by the DPU that reflects the date and time the system or any subsystem failed, and when it was returned to service.

(d) DCP and DPU software identification and version number(s).

(e) Raw (unprocessed) AWOS sensor data. Separate files shall be maintained for each sensor. The raw sensor data shall be available for retrieval to satisfy a one-time request, and shall also be available for schedule retrieval on a periodic (one, 15, 30, 60 minute) basis. The raw sensor data samples used by the DPU to process the weather algorithm at the time of retrieval shall be available for retrieval. For example (paragraph numbers refer to paragraphs in Appendix 12-10):

1.2.1(b). Data samples used to compute the two minute running average for wind speed. Same information for wind direction.

1.2.4.1(b). Data samples used to compute the one-minute average P1. Same information for P2.

1.2.5. The last 30 minutes of all ceilometer data samples.

(f) AWOS-generated RMM information (four hours of data shall be archived).

(g) A history (action, time, person) of any modifications to the system (paragraph 12-2.2.1.6.4).

(h) AWOS observation output.

- Each minute for the last 15 minutes
- Every five minutes for the last hour
- Hourly, for the last four days

(i) The number of incoming calls recorded by the telephone answering device (paragraph 12-2.2.2.5.1(a)).

<u>12-2.2.1.6.6 Perform maintenance diagnostics</u>.- The RMM parameters of the entire system shall be available through the MDT and the OT. Through use of this information and appropriate keyboard entries, system faults shall be isolated to the LRU level as required in Part 1, paragraph 1-3.5.4.3.2 and Part 19, paragraph 19-2.2.

<u>12-2.2.2 Hardware</u>.- In order to accomplish the above functions, the DPU shall satisfy the following hardware requirements:

<u>12-2.2.2.1 Interface ports</u>.- Interface port requirements are described in Part 19, paragraph 19-2.1.1. The DPU shall contain expansion capability for 50 percent more ports than necessary to accomplish the requirements of this specification.

<u>12-2.2.2.2 Memory</u>.- The DPU will contain 50 percent more memory than necessary to accomplish the requirements of this specification, for future growth. The DPU typically contains the following types of memory:

(a) The EPROM shall contain all DPU programs, default system parameters (e.g., location, identification and name; altitude of field; system configuration, etc.), algorithm constants, and the software version number.

(b) The RAM shall contain the variable system parameters, status, archived data and maintenance information. This memory shall be protected with a rechargeable battery source capable of retaining the memory (to include information required for system restart initialization) for a period of 4 hours.

(c) Current weather data input from the sensors, and DPU calculations shall be stored in a RAM.

<u>12-2.2.2.3 Real time clock</u>.- Coordinated Universal Time (UTC) shall be a product of the DPU, to indicate the time that the data was processed. Days, hours, minutes and seconds shall be provided as a system output for use in system displays, synthesized voice output, etc. The day shall be expressed in the Gregorian Calendar. Hours and minutes shall be indicated numerically from 0000 to 2359 with the H+00 observation being the hourly data. The clock function shall be accurate within 15 seconds a month. The clock shall be adjustable through the MDT, the OT and the RMMS (e.g., the AWOS shall accept a time command from the RMMS and shall adjust the time accordingly). The clock function shall have a battery power source to maintain real time for a period of 30 days in the event of an ac primary power failure.

<u>12-2.2.2.4 Processor(s)</u>.- Enough processing power in the DPU must be available to meet all specified functions with 50 percent excess in processing time.

The following normal response times shall be achieved:

(a) Observation processing time: less than 20 seconds.

(b) Voice dial-up response time: See paragraph 12-2.2.2.5.

(c) The digital data response time shall be less than 1 second to begin the transmission. It shall include the time required to load a peripheral data buffer (in a video display monitor, for example) with data from the DPU and for a formatted display to appear.

12-2.2.2.5 Computer generated voice and telephone answering unit.- This unit shall receive the digitized weather data directly from the DPU and shall use these data to originate a high quality computer generated voice message. The voice unit shall be collocated with the DPU for dial-up response and to provide the voice message for a ground-air radio broadcast. It shall have the capability for the addition of a manually input (analog) voice message from the OT (a maximum of 30 seconds duration) at the end of the computer generated message. The unit shall use the digital weather product to generate a high quality computer generated voice message. It shall incorporate an error checking scheme to prevent erroneous outputs resulting from the transfer of digital data and the development of the voice message.

12-2.2.2.5.1 Performance. - The voice unit shall contain the functions of speech generation and processing. Voice output shall be a balanced, low-impedance driver providing a nominal 1 milliwatt of power into a 600-ohm line. The output amplitude shall be adjustable (±12db) with a nominal 0 dbm output. The output shall be capable of driving unconditioned (30002) telephone lines, dial or dedicated. The voice generator shall have the following features:

(a) The computer generated voice message shall be output continuously with approximately a 5 second delay between the completion of one weather observation and the beginning of the next.

The telephone answering device shall respond (answer) by the end of the second ring, and the AWOS message will begin (in mid-message, if necessary) within five seconds thereafter. Two complete AWOS messages will be broadcast before automatically terminating the call. A counter will be included in the system to count and report (paragraph 12-2.2.2.1.6.5(i)) the total number of incoming calls each 24 hours (0000-2359 hours).

(b) If the voice message is in process of output when a new AWOS observation is received, the output message will be completed without interruption; voice transmission of the new AWOS observation will begin upon completion of the next delay time.

(c) The clarity and phrasing of the automated speech shall provide high intelligibility from telephone and ground-air radio transmitters. The intelligibility shall be a minimum of 90% (2400 bits per second) as measured by the Diagnostic Rhyme Test (DRT). The quality of the automated speech shall be a minimum of 50 (2400 bits per second) as measured by the Diagnostic Acceptability Measure (DAM). The quality of speech shall not be degraded when transmitted over a VOR or NDB.

(d) The format and sequence of the voice message shall be in accordance with FAA-ORD-7110.10, Flight Services Handbook. The time of the observation in Zulu shall be given after the location identification. The voice generator shall have the capability to prefix the voice message with "this is a test", when necessary. When any weather parameter is reported "MSG" (missing) by the DPU (due to a disabled sensor or an inoperative sensor, as determined by internal AWOS checks) and not augmented by a manual input, the voice report shall be "(parameter) MISSING," e.g., "WIND SPEED MISSING," "CLOUD HEIGHT MISSING," etc. When the parameter has been augmented with a manual input by an observer, the parameter shall not be reported "missing", and the observer's observation shall be announced in the manual input segment as "comments".

(e) In the event that a valid data update is not received prior to the start of the next voice transmission, the last valid data set received shall be used to compose the voice message. Failure to receive a data update for more than five minutes shall result in the termination of the voice output and generation of a failure message to the RMM system. In this event, the voice generator shall output the message "(station identification) automated weather observing system temporarily inoperative."

(f) The voice unit shall contain circuits necessary for remote monitoring of its status. See Part 1, paragraph 1-3.5.4.3.2 and Part 19, paragraph 19-2.2.

(g) The voice system shall contain a speaker and a headset jack for monitoring the voice output.

<u>12-2.2.2.5.2 Microcomputer</u>. - An industry-standard microprocessor/microcomputer shall control operation of the voice subsystem. It shall store the latest weather observations in memory, compose the voice message from the stored vocabulary and output the data to the voice generator for conversion to speech. Operating system routines for the microcomputer shall be stored in non-volatile memory.

<u>12-2.2.2.5.3 Speech generator</u>. - A voice generator shall receive data words from the microcomputer and convert them to an analog signal representing speech. The technique used shall be any technique yielding high quality speech.

<u>12-2.2.2.5.4 Message memory</u>. - The voice unit shall be able to accommodate a two-line observation (160 characters per observation).

12-2.2.2.5.5 Vocabulary. - The vocabulary shall include all words necessary to implement the algorithms (Appendix 12-I) and to produce a voice message in accordance with FAA-ORD-7110.10. The vocabulary will be supported in the firmware. The voice unit will have a capability to provide an eventual 400-word vocabulary to support AWOS expansion that includes RVR reporting and the following sensors: Thunderstorm, present weather, laser weather identifier, obstruction to vision, freezing precipitation, and runway surface condition. The vocabulary unique to a site (e.g., station identifier) shall be stored in a PROM.

12-2.2.2.6 DPU Controller.- The internal functioning of the DPU, and the interface with external subsystems shall be under the control of a DPU controller. In the case of a power failure, DCP/DPU communication failure or error, or any other disruption of DCP/DPU operation, upon alleviation of the disruption the DPU controller shall be automatically initialized to produce normal AWOS system operations. When this occurs, an identifying signal shall be provided to the RMM data.

12-2.2.2.7 Power monitoring and power reset.- The DPU shall constantly monitor AC and DC power associated with its operation. If any output power exceeds limits which could result in component damage, the source shall be either clamped or disconnected and an appropriate signal shall be sent to the RMM system data. When the power returns to normal, it shall be automatically reconnected.

12-2.2.2.8 Lightning/EMI Protection.- The DPU design shall include EMI/RFI protection, and line transient suppression and overvoltage protection devices (with automatic reset) on all input and output communication lines and power lines. See Part 1, paragraphs 1-3.3.3.5 and 1-3.3.3.6.

12-2.2.3 Software/firmware.- The guidelines for development of AWOS software/firmware presented herein are mandatory requirements for the contractor to fulfill.

12-2.2.3.1 Computer Software Quality Program Requirements.- The contractor shall establish and maintain a computer software quality program plan in accordance with FAA-STD-018. See Part 1, paragraph 1-4.1.1. Software documentation requirements are in Part 20.

12-2.2.3.2 Programming standards.- The AWOS shall be programmed in C language, except when absolutely necessary and approved by the FAA. Exceptions for functions not supported in C, for simplified routines (such as wind averaging), for off-the-shelf software or when execution time is critical will be considered for approval by the FAA on an individual basis, assuming that adequate software maintenance techniques are proposed. In addition, the programming techniques implemented shall be designed to maximize system transportability and legibility. All system modules, independent of language, shall conform to these standards. The number and complexity of characteristics required for any particular module depends on the module itself. System flexibility and documentation will be greatly enhanced by conforming during system development.

(a) System module characteristics.

(1) It shall perform only one function.

(2) It shall have a unique name.

(3) It shall constitute a single compilation or assembly.

(4) It shall have only one point of entry.

(5) It shall invoke a limited number of other modules.

(6) It shall not invoke itself.

(7) When called by another module, it shall return to the point immediately following the calling point, except in the case of error or abnormal return.

(8) It shall contain a limited number of decision paths.

(9) It shall not relinquish control to another module other than by call or by return to the module which called it, or by temporary suspension of operation through the services of the operating system or interrupts.

(10) It shall be documented as a unit.

(11) It shall be written and annotated so that the code can easily be related to the system design, module function, and algorithms.

(12) Its logic shall be as independent of the logic in all other modules except to the one calling it.

(13) It shall be serially reusable, i.e., no assumption shall be made regarding its previous execution.

(b) Module prologue - Each module shall include a preliminary section of comments containing all the information needed to evaluate the module design and to correlate the code with the design. As always, the module complexity dictates requirements. Each module prologue shall include:

(14) Change history - All module changes shall be identified by date, programmer, and purpose.

(15) Modification (destruction) of any register or memory data area shall be identified.

12-2.2.3.3 Top-down development.- Top-down development of software/firmware shall be adhered to by the contractor. Specific cases where this approach is not feasible shall be justified and subject to Government approval. Top-down development ideally consists of developing the highest level software/firmware units first, with the main control followed by routines called by the main routine. Following this, the next level of routines is developed. This process continues until the lowest levels are finished. At each stage, the routines to be called at the next lower level may be represented by program dummies, consisting of code to write a message (or otherwise indicate that the routine was called) and a return to the calling routine.

A system developed top-down can be tested from the start of development, as each level is finished. For example, the main control logic can be tested as soon as the main routine and the next level of dummy routines are available. Details of the lower-level routines can often (but not always) be ignored until it is time to complete them.

Despite the advantages, top-down development is not always feasible or desirable in practice. It may be necessary to determine details at lower levels first. In the methodology, a top-down approach is still taken, except that some lower-level routines or modules which depend on unproven capabilities are designed and coded early to assure their availability and minimize effects on design if changes are required.

12-2.2.3.4 Software modularity.- Modularity is one of the key factors in the maintainability and reliability of a system. Modularity refers to how a system is partitioned into subsets and the relationships among these subsets. Unfortunately, few definite guidelines may be stated for modularizing a system, since modularity is affected by such factors as the nature of input and output, processing, hardware, and programming considerations. The most common type of modularity is functional, in which units of code are based on specific software tasks. However, other divisions are possible and often preferable. Software modularity shall be adhered to by the contractor. Specific cases where this approach is not feasible shall be justified and subject to Government approval.

Regardless, systems shall be highly modular for even minimal maintainability. Additional advantages include easier debugging and testing, simplified documentation, and, for the AWOS, easier transportability and conditional configurations.

12-2.2.3.5 Staged implementation.- Rather then developing and testing a fully functional system, subsets shall be developed at the various levels so that individual functions become visible at an early point during development. Testing is facilitated and shall proceed concurrently with development. As each individual module is developed in the top-down development structure, it is included in the implementation. The earlier stages are subjected to considerable regression testing; thus, the amount of final testing is significantly reduced.

12-2.2.3.6 Software test documentation.- DOD-STD-2167 describes the requirements to be implemented to assure acceptable test documentation, a software management plan, and the identification of risk areas.

12-2.3 Reliability and maintainability.- The reliability and maintainability requirements for the DPU are as specified in Part 1.

12-2.4 Maintenance monitoring.- The contractor shall design an automatic maintenance monitoring, diagnostic and reporting system into the AWOS. See Part 1, paragraph 1-3.5.4.3.2 and Part 19, paragraph 19-2.2.

12-2.5 Built-in-Test (BIT) capability.- The contractor shall provide a BIT capability to diagnose maintenance problems.

12-2.5.1 General requirements. - The BIT capability shall be compatible with the RMM system, to include the RMM maintenance data terminal. It shall be capable of simulating the input signals, the DCP outputs, and shall have the system buss communication interfaces necessary to test the DCP and DPU subsystems. The simulations shall include data sets necessary to test the AWOS data processing algorithms. With the BIT, a trained technician shall be capable of isolating DCP, DPU and transmission (line, radio, etc.) failures and, after making repairs, recalibrate the system prior to restoring it to service. The BIT diagnostic capabilities must guide the technician to the unit, module, card, etc., requiring repair, replacement or calibration in a time short enough to meet the MTTR specifications.

12-2.5.2 Performance. - BIT shall perform the following functions:

(a) Collect the performance parameters of the AWOS (i.e., the DPU, the DCP and their own internal hardware and software elements and sensors) which are required for the determination for the equipment operational status. Identify equipment out-of-tolerance conditions and failures.

(b) Perform self-tests in order to check equipment and subsystem operation. In performing these tests, simulated data in the correct format shall be used as inputs to the appropriate AWOS elements (hardware or software) in order to test their proper operation. An example is a loop back test on the communication link.

(c) Perform demand tests and display the results and output from each subsystem under test in a form that is easily understood by the operator.

(d) Display constants (i.e., site specific parameters, alert limits, default setup) which are stored in EPROM.

(e) Check the operation of the DPU RAM.

(f) Check the DCP, DPU (and other subsystem) software operation.

(g) Check the operation of the DPU, DCP, sensors, personality modules and A/D converters.

(h) Provide software functions at the MDT to allow the operator to select the type of demand test to be performed, to input test data, or to call up display of any other parameter necessary for testing and calibration.

12-3 Testing

12-3.1 Data processing unit tests. - Tests of the AWOS DPU shall be performed in three stages.

(1) Digital data sets supplied by the Government shall be input to the DPU to verify accurate and correct operation of the algorithms. Fixed and variable data sets shall be provided to exercise the DPU over the full range of possible sensor inputs, and shall include various overrange and abruptly changing data to check the parameter quality control routines. Smaller data subsets shall be run with the DPU operating in extreme environmental conditions.

(2) Analog data sets (or digital data sets, if sensor output is digital) corresponding to the digital data above shall be input to the DCP to verify accurate and correct operation of the data acquisition subsystems when connected to the DPU.

(3) A full complement of actual sensor devices shall be connected to the DPU through a DCP and driven by actual or simulated weather conditions to verify accurate and correct operation of the entire AWOS unit. The sensors shall have passed their individual performance/acceptance tests. Data outputs from the DPU shall meet the same standards of accuracy as have been established for the sensors in their individual parts of this specification.

(4) Compatibility with the RMM system, including interface with the maintenance data terminal and the MPS.

(5) The unit shall also demonstrate the capability to output (both voice and digital) thunderstorm information input from the ADAS.

<u>12-3.2 Computer generated voice and telephone answering unit tests</u>.- The tests shall demonstrate compliance with the voice unit specifications by demonstrating, as a minimum, the following:

(a) Capability to generate all combinations of words corresponding to possible AWOS output reports.

(b) Detection of communication transmission errors, data loss, and cessation of voice transmission after loss of updates.

(c) Operation of RMM functions.

(d) Transmission of the manually input (from the OT) voice message at the end of computer generated voice AWOS message.

<u>12-3.2.1 Voice quality tests</u>.- The FAA Voice Response System (VRS) provides the quality of computer generated voice acceptable for the AWOS. Four tests shall be performed with the intent of demonstrating that the quality of the AWOS voice is equal to or greater than the VRS. In the first two tests, the quality of the AWOS voice shall be compared to the quality of an FAA prerecorded tape of a weather observation message (or of elements (phrases) of a weather observation message) from the VRS.

<u>12-3.2.1.1 Objective test</u>.- Five pilots shall listen to a prerecorded tape of VRS voice reciting 50 phrases typical of a weather observation message. These same pilots shall listen to a set of 50 similar phrases generated by the AWOS voice generator. The pilots shall log what they hear; each phrase shall be graded either correct or incorrect.

(a) The percentage of correct answers for each set of 50 phrases by each pilot shall be determined.

(b) For each pilot, compute the difference (d) in scores, VRS minus AWOS. Compute the mean difference ($\bar{d}$) and the standard deviation (σ) of the sample. The significance level (α) is established at 0.01.

(c) It is assumed that the sample has a normal distribution. Letting N equal the number of observations (5), the statistic t has a t(N - 1) distribution.

(d) Compute the statistic $t = \dfrac{\bar{d}}{\sigma/\sqrt{N}}$.

(e) The AWOS voice shall be acceptable if the statistic t is less than $t_{1-\alpha}(N - 1)$.

12-3.2.1.2 Subjective test.- Five pilots shall compare a prerecorded tape of the VRS voice reciting 10 weather observation messages to the same 10 observations generated by the AWOS.

(a) Each pilot shall rate the AWOS voice subsystem against the VRS in 5 categories: naturalness (includes phrasing and silent intervals), pleasantness, speech rate, freedom from extraneous noises, and understandability. Each category shall be rated from 1 to 7, as follows:

1. much less
2. less
3. slightly less
4. no difference
5. slightly greater
6. greater
7. much greater

(b) The score for each pilot shall be tabulated by adding his score for the 5 categories.

(c) The mean score (μ) and standard deviation (σ) for all pilots (N = 5) shall be computed. The significance level (α) is established at 0.01.

(d) Compute the statistic $t = \dfrac{\mu}{\sigma/\sqrt{N}}$.

(e) The AWOS voice shall be acceptable if the statistic t is greater than $t_{\alpha}(N - 1)$.

12-3.2.1.3 Diagnostic Rhyme Test (DRT).- The contractor shall develop a test to demonstrate speech intelligibility (paragraph 12-2.2.2.5.1 (c)) as determined by the DRT.

12-3.2.1.4 Diagnostic Acceptability Measure (DAM).- The contractor shall develop a test to demonstrate speech quality (paragraph 12-2.2.2.5.1(c)) as determined by the DAM.

APPENDIX 12-I

ALGORITHMS

This appendix contains the document that describes the Government-furnished algorithms to be implemented in the AWOS.

AUTOMATED WEATHER OBSERVING SYSTEM (AWOS)

ALGORITHMS

1.1 General. - This document contains the Government-furnished algorithms to be used to derive weather observations for the AWOS.

If less than 75 percent of the maximum amount of data used in the computation of any parameter is available, the parameter shall be reported as "missing". This is in addition to other conditions for "missing" described elsewhere in these algorithms and those performed under data reduction checks.

All parameters are updated on a one-minute cycle, except for wind, which has a 5-second update, and the 12-hour average temperature, which has an hourly update.

Preprocessing of data from sensors with short time constants may be necessary to obtain averages for use in these algorithms. For example, it may be necessary to sample the temperature sensor every 10 seconds and compute a one-minute average for use in the temperature algorithm.

All midpoint values are rounded down.

1.2 Algorithms

1.2.1 Wind speed ($\overline{WS}$) and direction ($\overline{WD}$) algorithms. - Wind speed ($\overline{WS}$) and wind direction ($\overline{WD}$) are 2-minute running averages calculated from sensor readings taken at one-second intervals. They are calculated as follows:

(a) Each second, interrogate the wind speed and direction sensors.

(b) Each 5 seconds, compute a 2-minute running average (scalar average) for speed ($\overline{WS}$) and direction ($\overline{WD}$). $\overline{WD}$ shall be rounded to the nearest 10 degrees (from 10 to 360 degrees) and $\overline{WS}$ shall be rounded to the nearest knot.

(c) When $\overline{WS}$ is less than or equal to 2 knots, indicate calm for $\overline{WD}$ and $\overline{WS}$.

1.2.1.1 Wind gust (G) algorithm. - Wind gust (G) is based upon the highest 5-second average wind speed for the past 10 minutes. It is calculated as follows:

(a) Each 5 seconds, compute a 5-second average wind speed.

(b) Each 5 seconds, store the 5-second average wind speeds for the past minute.

(c) Each 5 seconds, compare the current 2-minute average wind speed ($\overline{WS}$) and the highest 5-second average for the past minute. If $\overline{WS}$ equals or exceeds 9 knots, and the difference between the highest 5-second average wind speed and $\overline{WS}$ equals or exceeds 5 knots, store the highest 5-second average wind speed as G.

(d) Each 5 seconds, compare the current $\overline{WS}$ and the highest G (if any) stored during the past 10 minutes. If the highest G is at least 3 knots higher than the current $\overline{WS}$ and $\overline{WS}$ is not calm, report G.

<u>1.2.1.2 Variable wind direction algorithm</u>. - Variable wind direction is a wind direction which varies around the 2-minute average wind direction ($\overline{WD}$) by 60 degrees or more. It is calculated as follows:

(a) Each 5 seconds, calculate a 5-second average wind direction. Round this average direction to the nearest 10 degrees (from 10 to 360 degrees).

(b) Each minute, if the current 2-minute average wind speed ($\overline{WS}$) is greater than 6 knots, compute the range of the 5-second average wind directions on each side of $\overline{WD}$.

(c) If the total range is 60 degrees or more, indicate a variable wind direction. Indicate the 5-second average wind direction extremes (rounded to the nearest 10 degrees) in a clockwise direction around and including $\overline{WD}$.

<u>1.2.2 Temperature algorithms</u>

(a) Ambient temperature ($\overline{T}$). Ambient temperature ($\overline{T}$) is a 5-minute average temperature calculated each minute from sensor readings taken at least once each minute. It is calculated as follows:

(1) At least once each minute, obtain the temperature from the ambient temperature sensor.

(2) Each minute, compute a 5-minute average (rounded to the nearest degree) and indicate this temperature ($\overline{T}$). If 5 one-minute values are available, compute $\overline{T}$ based on the 5 values. If only 4 one-minute values are available, compute $\overline{T}$ based on the 4 values (i.e., divide by 4). If less than 4 valid one-minute values are available, do not compute a current $\overline{T}$. Instead, use the most recent $\overline{T}$ computed within the past 15 minutes as the current $\overline{T}$. If no computed $\overline{T}$ values are available within the past 15 minutes, indicate the current $\overline{T}$ as missing.

(b) Twelve-hour average ambient temperature ($\overline{T}12$).

(1) Each hour on the hour (i.e., at 0000, 0100, 0200, etc.), compute an average of the current $\overline{T}$ and $\overline{T}$ computed on the hour 12 hours ago. This is $\overline{T}12$.

(2) Store $\overline{T}12$ for use in the sea level pressure algorithm.

1.2.3 Dew point ($\overline{T}d$) algorithm. - Dew point temperature ($\overline{T}d$) is a 5- minute average dew point temperature calculated each minute from sensor readings taken at least once each minute. It is calculated as follows:

(a) At least once each minute, obtain the dew point from the dew point sensor.

(b) Each minute, compute a 5-minute average dew point (rounded to the nearest degree) and indicate this dew point ($\overline{T}d$).

(c) If $\overline{T}d$ is 1 or 2 degrees higher than the 5-minute average temperature ($\overline{T}$), indicate $\overline{T}d$ equal to $\overline{T}$. If $\overline{T}d$ exceeds $\overline{T}$ by more than 2 degrees, indicate $\overline{T}d$ missing. If $\overline{T}$ is missing, indicate $\overline{T}d$ missing.

1.2.4 Pressure. - The AWOS includes at least two pressure sensors for quality control purposes.

The following definitions apply to AWOS installations:

Altimeter setting (AS) - The pressure value to which the altimeter of an aircraft on the ground is set so that it will indicate the field elevation (mean sea level) of the airport.

Field elevation (Ha) - The officially designated field elevation of an airport above mean sea level. It is the elevation of the highest point on any of the runways of the airport.

Density altitude (DA) - The altitude in the standard atmosphere where air density is the equivalent to that at the airport.

Pressure reduction ratio (r) - The ratio used to convert station pressure to sea level pressure. These values, in increments of 10°F, will be provided by the Government individually for each station. Linear interpolation of the"r" values to the nearest 1°F for computation of sea level pressures shall be performed in the system software. Note: Reduction constants, "c", are used instead of "r" at some locations where the station elevations are within approximately 50 feet of mean sea level. Reduction constants (c) will be provided by the Government in lieu of pressure reduction ratios (r) for applicable locations.

Zero point (Hz). - The height of the pressure sensor zero point above mean sea level.

Sensor pressure (P) - The atmospheric pressure at the actual elevation of the sensor (Hz).

Field pressure (Pa) - The atmospheric pressure computed for field elevation (Ha).

Station pressure (Ps) - The atmospheric pressure computed for the level of the station elevation (Hp). Station pressure (Ps) is equal to field pressure (Pa) for AWOS installations located at airports.

Sea-level pressure (SLP) - The atmospheric pressure at mean sea level. It may either be measured directly or, most commonly, computed from the station pressure.

Station elevation (Hp) - The officially designated height above mean sea level to which station pressure (Ps) pertains. Hp is the same as Ha for AWOS installations located at airports.

<u>1.2.4.1 Field pressure (Pa) algorithm</u>. - Field pressure (Pa) is computed from the lowest of at least two one-minute average sensor pressures ($\overline{P}$) and use of the hypsometric equation. Pa is calculated as follows:

(a) Each 10 seconds, read the two pressure sensors (located at elevation Hz) to the nearest 0.005 inHg. These values are P1 and P2.

(b) Each minute, compute a one-minute average for P1 and P2. These are $\overline{P}1$ and $\overline{P}2$.

(c) Each minute, compare $\overline{P}1$ and $\overline{P}2$. If $\overline{P}1$ and $\overline{P}2$ differ by more than 0.04 inHg, consider pressure as "missing" and do not compute any pressure dependent parameters.

(d) Each minute, using the <u>lower</u> of $\overline{P}1$ and $\overline{P}2$, compute field pressure (Pa) using the equation:

$$Pa = \overline{P} \times 10^{(KH/\overline{T}r)}$$

Where: $\overline{P}$ = Lower of $\overline{P}1$ and $\overline{P}2$

K = 0.008135

H = Difference, in feet, between the elevation of the pressure sensors (Hz) and the field elevation of the airport (Ha).

$\overline{T}r$ = Current 5-minute average temperature ($\overline{T}$) in degrees Rankine, i.e., $\overline{T}r = \overline{T} + 459$.

<u>1.2.4.2 Altimeter setting (AS) algorithm</u>. - Altimeter setting (AS) is calculated from field pressure (Pa) and field elevation (Ha) as follows:

(a) Each minute, calculate the altimeter setting (AS) using the equation:

$$AS = (Pa^{N} + KHa)^{1/N}$$

Where: Pa = Field pressure
N = 0.190263
$1/N$ = 5.25588
K = 1.3126×10^{-5}
Ha = Field elevation of the airport in feet above mean sea level.

(b) If Pa is missing because $\overline{T}r$ is missing, compute AS using the equation:

$$AS = (\overline{P}^{\,N} + KHz)^{1/N}$$

Where: $\overline{P}$ = Lower of $\overline{P}1$ and $\overline{P}2$
N = 0.190263
$1/N$ = 5.25588
K = 1.3126×10^{-5}
Hz = Elevation of the pressure sensors in feet above mean sea level.

(c) Round to the nearest 0.01 inHg.

1.2.4.3 Density altitude (DA) algorithm. - Density altitude (DA) is calculated from field pressure (Pa) and the temperature in degrees Rankine ($\overline{T}r$) as follows:

(a) Each minute, compute DA in feet using the equation:

$$DA = 145{,}366\left[1 - \left(\frac{17.326\,(Pa)}{\overline{T}r}\right)^{0.235}\right]$$

Where:
Pa = Field pressure to the nearest 0.01 inHg
$\overline{T}r$ = Current 5-minute average temperature ($\overline{T}$) in degrees Rankine, i.e., $\overline{T}r = \overline{T} + 459$.

(b) Report DA to the nearest 100 feet when DA is more than 1000 feet above field elevation (Ha).

(c) If DA cannot be computed (e.g., Pa and/or $\overline{T}r$ missing), report DA as missing.

1.2.4.4 Sea-level pressure (SLP) algorithm. - Sea-level pressure (SLP) is calculated from field pressure (Pa), which is the same as station pressure (Ps) for AWOS installations located at airports, and a pressure reduction ratio (r) or a pressure reduction constant (c) as follows:

(a) Each minute, calculate the sea level pressure (SLP) in millibars using the equation:

SLP = 33.8639 (Pa) (r)

Where: Pa = Field pressure to the nearest 0.01 inHg.

r = Pressure reduction ratio. This ratio is determined each minute using the table of "r" values provided by the Government and the 12-hour average temperature ($\bar{T}12$) computed on the hour. For example, "r" at 20 minutes past the hour is computed from the table of "r" values using the $\bar{T}12$ value computed on the hour. Linear interpolation of the "r" value to the nearest 1°F is required.

(b) Round SLP to the nearest 0.1 millibar.

(c) For some stations within approximately 50 feet of mean sea level, SLP = 33.8639 (Pa) + c, where "c" is the reduction constant.

1.2.5 Ceiling/sky condition algorithm. - Ceiling and sky condition are determined from sensor outputs at least every 30 seconds integrated over a 30-minute sample period. A weighting scheme is employed for data collected during the last 10 minutes of the 30-minute sample period to make the algorithm more responsive to rapid changes in ceiling/sky conditions. Heights are reported in hundreds of feet (e.g., 30 represents a height of 3,000 feet). Ceiling and sky condition are determined as follows:

1.2.5.1 Data collection

(a) At least once every 30 seconds, sample the cloud height sensor.

(b) At least once each 30 seconds, store the lowest cloud height, obscuration aloft height, contact height (CH), or vertical visibility (VV) detected (i.e., hit) or negative response (i.e., no hit).

(c) At least once each 30 seconds, round the lowest hit to the nearest 100 feet, except hits within 500 feet of the design range of the sensor shall be rounded down to the nearest 1000 feet, e.g., hits between 12,000 and 12,500 feet are rounded to 12,000 feet. Midpoint values shall be rounded down, except hits at 50 feet or less are rounded up to 100 feet.

(d) At least once each 30 seconds and after rounding, assign hits to bins established as specified below. Hits midpoint between bins shall be assigned to the lower bin.

(1) Surface to 5,000 feet: Use 100-foot bins starting with 100 feet (i.e., 100, 200, 300... etc...5,000).

(2) Above 5,000 feet: Use 200-foot bins (i.e., 5,000, 5,200, 5,400... etc...12,000).

1.2.5.2 Weighting

(a) Each minute, add the following to obtain the total number of weighted possible hits during the past 30 minutes. Include those scans when a hit was detected as well as those when no hit was detected, except exclude those scans when no hit was detected due to a sensor error/fault.

(1) 20 times the number of sensor scans per minute during the most recent 10-minute period; plus

(2) 20 times the number of sensor scans per minute for the 20 minute period preceding (1).

(b) Actual hits for the most recent 10-minute period shall be counted as two hits. Hits during the preceding 20-minute period shall be counted once.

1.2.5.3 Clustering bins. - Each minute, cluster bins established during the 30-minute sampling period using the following criteria:

(a) Determine the number of bins (paragraph 1.2.5.1(d)). If there are 5 or less bins, go to paragraph 1.2.5.4 (combining clusters), otherwise continue.

(b) The bins shall be ordered from the lowest to the highest height.

(c) Calculate the least square distance between all adjacent bins using:

$$D = \left(\frac{N(J) \times N(K) \times [H(J) - H(K)]^2}{N(J) + N(K)} \right)^{1/2}$$

Where:

D = least square distance
H = bin height
N = number of hits in that bin
(J) = bin for the higher height
(K) = bin for the lower height

(d) Combine the two adjacent bins having the smallest least square distance. If more than one pair of bins have the same least square distance, combine the pair with the lowest height.

(e) Combine the bins using the formulas below:

$$\text{HEIGHT:}\quad H(L) = \frac{\left[N(J) \times H(J)\right] + \left[N(K) \times H(K)\right]}{N(J) + N(K)}$$

$$\text{NUMBER OF HITS:}\quad N(L) = N(J) + N(K)$$

Where H(L) is the height of the combined bin rounded to the nearest bin height in paragraph 1.2.5.1(d), and N(L) is the number of hits for the combined bin.

(f) The H(L) and N(L) bin shall replace the H(J), H(K), N(J) and N(K) bins. Now, if there are more than 5 bins (or clusters), return to step (b). Otherwise, continue to the next step (combining clusters).

<u>1.2.5.4 Combining Clusters</u>. - Each minute, after clustering of bins has been completed, determine if the clusters can be combined using the following criteria:

(a) Group the clusters in ascending order.

(b) Compute the height difference of all adjacent clusters.

(c) If the lower height of any adjacent pair is equal to or less than 1,000 feet, and the difference between heights is 300 feet or less, go to (g) and combine the clusters. If the difference is greater than 300 feet, continue to the next pair.

(d) If the lower height of any adjacent pair is greater than 1,000 feet, and the difference between heights is 400 feet or less, go to (g) and combine the clusters using the equations. If the difference is greater than 400 feet, continue to the next pair.

(e) If the lower height of any pair is greater than 3,000 feet, and the difference between heights is 500 feet or less, go to (g) and combine the clusters. If the difference is greater than 500 feet, continue to the next pair.

(f) If the lower height of any adjacent pair is 5,000 feet or higher, and the difference between heights is 800 feet or less, go to (g) and combine the clusters. If the difference is greater than 800 feet, continue to next pair.

(g) Combine the clusters using the equations in paragraph 1.2.5.3(e).

(h) When two clusters are combined the new cluster height shall be rounded and assigned a height as specified in paragraph 1.2.5.1(d). The new cluster shall replace the two that were combined, the clusters reordered and the process of combining continued (i.e., return to (a), above). All adjacent pairs shall continue to be examined until no further combining is possible.

(i) At the end of this combining process, all cluster heights shall be rounded as specified below. Midpoint values shall be rounded down. Cluster heights shall now be referred to as H_C.

(1) Heights surface to 5,000 feet - nearest 100 feet starting with 100 feet (i.e., 100, 200,...etc...5,000)

(2) Heights 5,000 to 10,000 feet - nearest 500 feet (i.e., 5,000, 5,500, 6,000...etc...10,000)

(3) Heights above 10,000 feet - nearest 1,000 feet (i.e., 10,000, 11,000, 12,000)

1.2.5.5 Computation of cloud amount

(a) Obtain the total number of weighted possible hits from paragraph 1.2.5.2.

(b) Calculate the cluster factors (R_C) using the following formula for each cluster, starting with the lowest cluster at height H_C.

$$R_C = \frac{\text{Number of Weighted Cluster Hits}}{\text{Weighted Possible Hits}}$$

(c) If R_C of each cluster is less than 0.06 or there are no clusters (i.e., no hits), and the visibility ($\overline{V}$) rounded to the nearest reportable value (paragraph 1.2.6.2(g)) is:

(1) "Missing" and $\overline{T}$ minus $\overline{Td}$ is equal to or less than 4 degrees, or if either $\overline{T}$ or $\overline{Td}$ is missing, indicate the ceiling/sky condition as "missing". If $\overline{T}$ minus $\overline{Td}$ is 5 degrees or more, indicate no clouds below the design range of the sensor.

(2) Less than 1/4 mile, indicate an indefinite zero obscured ceiling/sky condition (i.e., W0X).

(3) Equal to or greater than 1/4 mile, but less than 1/2 mile, indicate an indefinite 200 foot obscured ceiling/sky condition (i.e., W2X).

(4) Equal to or greater than 1/2, but less than one mile, indicate an indefinite 500 foot obscured ceiling/sky condition (i.e., W5X).

(5) Equal to or greater than one, but less than two miles and precipitation (as reported in the AWOS observation) is :

a Reported, indicate an indefinite 700 foot obscured ceiling/sky condition (i.e., W7X).

b Not reported or missing, indicate a partially obscured sky condition, (i.e., -X).

(6) Equal to or greater than two miles, indicate no clouds below the design range of the sensor.

(d) If R_C of any cluster at height H_C is equal to or greater than 0.06, calculate the cloud cover factor, R_L, for each cluster (hereafter referred to as layer) height using the following formula, starting with the lowest layer.

$$R_L = \frac{\sum_{L=1}^{N} \text{(WEIGHTED ACTUAL LAYER HITS)}}{\text{WEIGHTED POSSIBLE HITS}}$$

Where: N = Layer number starting with the lowest layer

Weighted Actual Layer Hits = Number of weighted hits, paragraph 1.2.5.2(b), in the layer at height H_C.

Weighted Possible Hits = Number of possible hits calculated per paragraph 1.2.5.2(a).

(e) If there is more than one layer, apply the summation principle. For example, if a lower layer at height H_{C1} has 25 weighted hits and the next layer at H_{C2} has 13 weighted hits, R_L for H_{C2} would be computed using 38 for the number of weighted hits in that layer. Exception: If R_L for any layer is less than 0.06, the number of hits in that layer is not added to any other layer. However, the total number of weighted possible hits (paragraph 1.2.5.2(a)) shall not be reduced.

(1) Add the following factors to the R_L value for each layer based upon the visibility value ($\overline{V}$) rounded to the nearest reportable value (paragraph 1.2.6.2(g)).

a If $\overline{V}$ is less than or equal to 1/4 mile, add 0.6. Preface the ceiling/sky condition with "-X" (partially obscured).

b If $\overline{V}$ is greater than 1/4 but equal to or less than one mile, add 0.4. Preface the ceiling/sky condition with "-X" (partially obscured).

c If $\overline{V}$ is greater than one but equal to or less than two miles, add 0.2. Preface the ceiling/sky condition with "-X" (partially obscured).

d If $\overline{V}$ is greater than two but less than three miles, no adjustment is made. However, the ceiling/sky condition is prefaced with "-X" (partially obscured).

e If $\overline{V}$ is equal to or greater than three miles, the ceiling/sky condition is not prefaced with "-X" (partially obscured).

f As a result of the additive factors specified in paragraphs a, b and c, above, R_L may exceed 1.0. If so, truncate R_L at 1.0.

(2) If the current R_L is equal to or greater than 0.45 but less than 0.50, and the R_L height is within 200 feet of the height of the lowest broken layer for the previous minute, add 0.05 to the current R_L.

(3) Each minute, using the current R_L value (as modified by paragraphs (1) and (2), above) report layers as follows:

a If the R_L is equal to or greater than 0.06 but less than 0.50, the layer shall be reported as scattered.

b If R_L is equal to or greater than 0.50 but equal to or less than 0.87, the layer shall be reported as broken.

c If R_L is greater than 0.87, the layer shall be reported as overcast:

1.2.5.6 Reporting cloud layers and their priority

(a) If R_L is less than 0.06, report no clouds below the design range of the sensor.

(b) Obscured ceilings/sky conditions are reported as specified in paragraph (1.2.5.5(c)).

(c) Partially obscured sky conditions are reported as -X. "-X" shall also be used to prefix ceiling/sky condition as specified in paragraph 1.2.5.5(e)(1).

(d) Up to three layers can be reported; however, if there is more than one overcast layer, the lowest is reported and the other(s) shall be disregarded.

(e) Layers shall be reported from the lowest to the highest using the height H_C assigned to each layer.

(f) If there are more than three layers, the three lowest layers shall be reported using the priority listed below:

(1) The lowest scattered layer.
(2) The lowest broken layer.
(3) The lowest overcast layer.
(4) The second lowest scattered layer.
(5) The second lowest broken layer.
(6) The highest broken layer.
(7) The highest scattered layer.

(g) Starting with the lowest layer, if for any layer reported, the height (H_C) is less than or equal to 5,000 feet and is within plus/minus 100 feet of a layer height reported for the previous minute, use the height (H_C) ascribed to the previous minute if that height value is unoccupied. If the height (H_C) of any layer is greater than 5,000 feet and is within plus/minus 500 feet of a layer height reported for the previous minute, use the height (H_C) ascribed to the previous minute if that height value is unoccupied. The sky condition designation (i.e., scattered, broken or overcast) shall not change as a result of these procedures.

1.2.6 Visibility

1.2.6.1 Photometer. - A photometer shall be provided with the visibility sensor to indicate day or night ambient light levels. The photometer establishes the setting of the "day/night switch" to determine whether the extinction coefficient computed by the visibility sensor is to be translated to visibility by a day or night equation.

1.2.6.2 Visibility ($\overline{V}$) algorithm. - Visibility ($\overline{V}$) is the horizontal visibility near the earth's surface representative of visibility conditions in the vicinity of the visibility sensor. It is determined from sensor outputs at 10-second intervals that are used to compute a one-minute average extinction coefficient. The one-minute extinction coefficient average is converted to a one-minute visibility (V) value through either a day or night visibility equation. The visibility (V) values are averaged (harmonic average) over a 10-minute period to determine $\overline{V}$. $\overline{V}$ is calculated as follows:

(a) Each 10-seconds, interrogate the visibility sensor.

(b) Each minute, compute a one-minute average extinction coefficient from the sensor outputs.

(c) Each minute, check the photometer for day/night status. If the photometer is not operational, set indication to day.

(d) Each minute, convert the one-minute average extinction coefficient value to visibility (V) rounded to the nearest 0.1 statute mile (from 0.1 to 10.0) using the following equations:

(1) For day V

$$V = 3/\sigma$$

(2) For night V

$$.00336 = \frac{e^{-\sigma V}}{V}$$

Where:

σ = extinction coefficient in miles^{-1}
e = 2.718

(e) Each minute, compute a 10-minute harmonic average of the visibility (V) values for the past 10-minutes. This is $\overline{V}$. The equation for a harmonic average is as follows:

$$1/\overline{V} = 1/n\ (1/V_1 + 1/V_2 + 1/V_3 \ldots 1/V_n)$$

Where:

n = Total number of V values

(f) Each minute, round $\overline{V}$ to the nearest reportable value given in (g), below. Values of $\overline{V}$ less than 0.2 are reported as less than 1/4; values equal to or greater than 0.2 but equal to or less than 0.375 are reported as 1/4.

(g) Reportable values for $\overline{V}$ are: less than 1/4, 1/4, 1/2, 3/4, 1, 1 1/4, 1 1/2, 1 3/4, 2, 2 1/2, 3, 3 1/2, 4,5,7, and 10.

1.2.6.3 Variable visibility algorithm. - Variable visibility is indicated when the 10-minute harmonic average visibility ($\overline{V}$) is less than 3 miles and the individual one-minute visibility values (V) vary by one or more reportable values during a 10-minute period. It is calculated as follows:

(a) Each minute, compare the current V with the V value for the preceding minute. If the difference between the V values is greater than 0.5 miles, maintain a file of the positive or negative changes. Note: For purpose of this file, V values are truncated at 5 miles, i.e., V values greater than 5 miles are treated as 5 miles.

(b) Each minute, examine the past 10 minutes of data. If the number of V changes in the file is equal to or greater than 3, and the sign of the change has changed at least twice, and the current $\overline{V}$ is less than 3 miles, indicate variable visibility in the form:

VSBY min V max

Where: Min = Minimum V value generated during the past 10 minutes and rounded to the nearest reportable value.

Max = Maximum V value generated during the past 10 minutes and rounded to the nearest reportable value.

1.2.7 Precipitation occurrence/type/accumulation/intensity algorithms

1.2.7.1 Precipitation occurrence/type algorithms. - Precipitation occurrence/type is determined from one-minute sensor outputs integrated over a 10-minute period. Three indications within 10 minutes are required to trigger the beginning of precipitation. Once started, precipitation is assumed to continue for at least 10 minutes. The end of precipitation is signaled when less than 2 indications occur in a 10 minute period; thus, precipitation is reported during intermittent conditions. Precipitation occurrence/type is determined as follows:

(a) Each minute, examine the sensor for an indication of precipitation occurrence and type during the past minute. Store this output.

(b) Each minute, examine the current output and the output for the most recent 10-minute period. If 3 positive indications of precipitation are generated within this 10-minute period, the type of precipitation is reported (Note: It is understood that precipitation is occurring when the type is reported).

(1) Only one type of precipitation is reported. The type reported is based upon the type(s) indicated during the most recent 10-minute period in accordance with the following priority.

Hail
Ice pellets
Snow
Rain
Drizzle
Precipitation (Type not determined)

(2) The initial precipitation type reported shall be the highest priority type of the 3 positive indications stored during the most recent 10-minute period.

(3) Once precipitation type is initiated, the type reported shall be the highest priority type stored during the most recent 10-minute period.

(4) Once precipitation type has been generated, a type shall be reported for at least 10 minutes.

(5) After the initial 10 minute period, precipitation occurrence/type is ended when less than 2 positive indications of precipitation are generated during a 10-minute period.

(6) Store the type of precipitation reported for use in the precipitation accumulation algorithm.

<u>1.2.7.2 Precipitation accumulation algorithm</u>. - Precipitation accumulation is the cumulative amount of liquid or liquid equivalent precipitation. The accumulation process starts and ends each hour on the hour (i.e., at 0000, 0100, 0200, etc.). Precipitation accumulation is reported each minute. Thus, the precipitation accumulation reported on the hour is the cumulative amount over the past hour or, if precipitation occurrence was not reported on the past hour, since precipitation occurrence was first reported. The amount reported between hours represents the cumulative amount since the accumulation process began on the hour to the time of the observation or, if precipitation occurrence was not reported on the hour, to the time precipitation occurrence was first reported. Precipitation accumulation is determined as follows:

(a) Each hour on the hour (i.e., at 0000, 0100, 0200, etc.), start and end the precipitation accumulation process.

(b) Each minute, interrogate the precipitation accumulation sensor and round the cumulative amount detected since the accumulation process began ((a), above) to the nearest 0.01 inch.

(c) Each minute, determine if precipitation occurrence is being reported.

(d) Each minute, indicate the precipitation accumulation as follows:

(1) None - None is indicated by the absence of an amount.

(2) Trace - Trace is indicated when the accumulation is less than 0.005 inch. Trace is also indicated when precipitation occurrence is currently being reported or has been reported since the accumulation process began, but no accumulated amount is detected by the precipitation accumulation sensor. Trace is indicated as 0.00.

(3) Amounts equal to or greater than 0.005 inch - Indicate the amounts to the nearest 0.01 inch in inches/tenths/hundredths, e.g., 1.02.

<u>1.2.7.3 Precipitation intensity algorithm</u>. - Precipitation intensity shall be indicated when a measurement of intensity is available from the precipitation sensor. The intensity indicated shall be for the

precipitation type determined per paragraph 1.2.7.1, above, except no intensity shall be reported for hail and precipitation (type not determined). Intensity shall be reported as light unless there are at least two indications of moderate or heavy intensity within the past 5 minutes. If there are at least two indications of moderate or heavy intensity within the past 5 minutes, moderate intensity shall be reported unless there are at least two indications of heavy intensity, in which case heavy intensity shall be reported.

1.2.8 Thunderstorm algorithm. - This algorithm assumes that lightning flash data are received from a network and processed into appropriate geographical areas before being sent to the AWOS. Thunderstorm occurrence is defined as occurring at the airport or in the appropriate octant(s) in the vicinity of the airport. Three or more cloud-to-ground lightning flashes occurring within 15 minutes within 10 nautical miles of the airport reference point (ARP) shall designate a thunderstorm at the airport. Three or more cloud-to-ground lightning flashes occurring within 15 minutes within an appropriate octant(s) shall designate a thunderstorm(s) in the vicinity of the airport. The ending of a thunderstorm at the airport or in one or more of the vicinity octants is defined as the absence of a cloud-to-ground lightning flash for 15 minutes in the appropriate area(s). Thunderstorm indication is determined as follows:

(a) Each minute, accept lightning flash data from the lightning detection network. Data from the network shall include time of the lightning flash and the appropriate bin area.

(b) Each minute, file lightning flash data into bin areas established as follows:

(1) At airport (ten nautical miles or less from the ARP).

(2) North (N) octant (more than 10 but 30 nautical miles or less from the ARP between the 337.5 and 022.5 radials).

(3) Northeast (NE) octant (more than 10 but 30 nautical miles or less from the ARP between the 022.5 and 067.5 degree radials).

(4) East (E) octant (more than 10 but 30 nautical miles or less from the ARP between the 067.5 and 112.5 radials).

(5) Southeast (SE) octant (more than 10 but 30 nautical miles or less from the ARP between the 112.5 and 157.5 degree radials).

(6) South (S) octant (more than 10 but 30 nautical miles or less from the ARP between the 157.5 and 202.5 degree radials).

(7) Southwest (SW) octant (more than 10 but 30 nautical miles or less from the ARP between the 202.5 and 247.5 degree radials).

(8) West (W) octant (more than 10 but 30 nautical miles or less from the ARP between the 247.5 and 292.5 degree radials).

(9) Northwest (NW) octant (more than 10 but 30 nautical miles or less from the ARP between the 292.5 and 337.5 degree radials).

(c) Each minute, count the number of lightning flashes in each bin area for the past 15 minutes. If the count is equal to or greater than 3, indicate a thunderstorm for that bin area(s). Once indicated, a thunderstorm is assumed to continue for at least 15 minutes.

(d) Each minute, in each bin area where a thunderstorm is indicated, determine the time of the most recent lightning flash. If the difference between the current time and the time of the most recent lightning flash is 15 minutes or less, continue to indicate a thunderstorm for that bin area. If the difference is more than 15 minutes, terminate the thunderstorm for that bin area.

1.2.9 Alert criteria. - The digital message from the AWOS shall contain an alert character(s) to be read by video devices to generate an appropriate alert. This character(s) shall identify the reason(s) for the alert (i.e., indicate the weather parameter(s) causing the alert). The requirements specified herein as "local requirements"shall be programmed into the system along with other site specific information before shipment of the system from the manufacturer. The criteria for generating alerts shall be as follows:

(a) Ceiling. - The ceiling forms or decreases to less than, or dissipates or increases to be equal to or greater than:

(1) 3000 feet
(2) 1000 feet
(3) 500 feet
(4) Local requirements (up to two additional values)

(b) Sky condition. - A layer of scattered clouds is present below:

(1) 1000 feet and no clouds were reported below 1000 feet in the preceding observation.

(2) Local requirement (up to one additional value)

(c) Visibility. - The visibility decreases to less than, or if below, increases to equal or exceed:

(1) 3 miles
(2) 2 miles
(3) 1 1/2 miles
(4) 1 mile
(5) Local requirements (up to four additional values)

(d) Precipitation or other weather phenomena. - Any type of precipitation or other weather phenomena begins or ends.

(e) Wind. - A change in wind direction when the wind speed is greater than five knots that would revise the landing runway to a new preferred direction. (The AWOS system shall be capable of accepting local requirements for up to six runway directions).

PART 13 - MAINTENANCE DATA TERMINAL

13-1 PURPOSE

This Part establishes the unique performance and test requirements for a maintenance data terminal for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification. The terminal shall be capable of performing all specified maintenance functions through the maintenance ports on the DCP and the DPU. The maintenance functions shall be performed with a microcomputer based CRT or keyboard that is IBM compatible.

13.2 REQUIREMENTS

13-2.1 Terminal specifications.- This device shall be a CRT/keyboard that is IBM PC compatible. The protocol standard shall be ANSI x3.64, American National Standard as implemented on an IBM PC (or compatible), using an asynchronous serial RS-232 interface. The keyboard shall be a commercially available product with documented reliability. It shall contain all 95 ASCII characters, and shall have an RS 232 interface capability. This device can be used with or without a printer.

13-2.2 Reliability and maintainability.- The reliability/maintainability requirements for the printer are as specified in Part 1.

13-3 Testing.- The contractor shall test the maintenance data terminal to demonstrate that it meets the stated performance requirements.

PART 14 - CONTROLLER VIDEO DISPLAYS

14-1 PURPOSE.- This part establishes the unique performance and test requirements for Air Traffic Controller Video Displays (CVD). These displays will interface with the DPU (Part 12) and/or the OT (Part 15) and will be used to display AWOS weather data to Air Traffic personnel. These displays must be functional (i.e., readable) in both high and low artificial and natural light conditions. The general requirements for AWOS contained in Part 1 form a part of this specification.

14-2 REQUIREMENTS

14-2.1 General.- The contractor shall provide the displays to be used by the air traffic controllers to review and add to or edit the weather observation prior to disseminating weather information to the pilot. The displays shall receive the incoming serial data stream, perform error checks on the data, and shall format and display the data. When used with an OT, the display shall also present the alpha character and time of the current AWOS observation, in addition to any weather observations augmented through the OT.

14-2.2 Type of display.- The CVD shall have high contrast characteristics, comparable to a high quality LCD or plasma display. It shall have an adjustable background luminance capability, and an adjustment to vary the brightness of panel controls.

14-2.3 Data display.- The CVD shall contain the display device, electronic driving circuitry, decoding and character generation device, and the interface and any other circuitry necessary to display the weather information selected by an FAA controller using an OT. The information to be displayed shall include: (a) airport identification, (b) UTC, (c) ALPHA code and time of update, (d) DPU output, as defined by the algorithms (Appendix 12-I), and (e) manually inserted comments. The CVD shall include a method for automatically highlighting (e.g., enclose in brackets; blinking data; reverse video, etc.) any manually entered data (weather data or comments) and any automatically or manually generated alert information (Part 15, paragraph 15-2.2.2(2)(e) and Appendix 12-I, paragraph 1.2.9). The exact format for displaying this information shall be approved during the Design Verification Reviews (Part 1, paragraph 1-4.3.1.3).

14-2.3.1 Data presentation.- The CVD shall have the capability to display the following data, as selected by an operator using an OT:

(a) The current AWOS weather data, to include the time (Part 12, paragraph 12-2.2.1.3.2(a)).

(b) The weather information being broadcast, to include the Alpha character identification and the time.

14-2.4 Functional requirements.- The CVD shall permit viewing in full, direct sunlight from any angle, as installed in an Air Traffic Control Tower. The display shall be readable in light levels from bright sunlight, artificial light, to near darkness, at a distance of 10 feet, and at a horizontal viewing angle to 30° either side and a vertical viewing angle to 20° either side from the perpendicular to the plane of the display.

14-2.5 Interface ports.- See Part 19, paragraph 19-2.1.1.

14-2.6 Reliability and maintainability.- The reliability/maintainability requirements for the CVD are as specified in Part 1.

14-3 Testing.- Testing shall be performed in accordance with the contractor developed, FAA approved Test Plan (Part 1, paragraph 1-4.2).

PART 15 - OPERATOR TERMINAL

15-1 PURPOSE

This Part defines the performance, configuration and test requirements for the Operator Terminal (OT) used by an operator to monitor the output and status of the system, augment and/or modify system outputs, append an analog voice addition to the AWOS voice observation message, control and display the AWOS Alpha character, reconfigure the system, receive and display system failure messages, and perform failure diagnostics. The general requirements for AWOS contained in Part 1 are a part of this specification.

15-2 REQUIREMENTS

15-2.1 General.- The OT shall include a video display terminal, keyboard, a headset jack and a speaker, microphone and any necessary OT-DPU processing interfaces. The OT shall enable an operator to perform the system control functions described in Part 12, paragraph 12-2.2.1.6 (e.g., monitor current output; retrieve data; put a parameter missing; add comments to end of the observation; provide maintenance diagnostic data; perform maintenance diagnostics).

15-2.1.1 OT configuration.- The OT configuration shall consist of:

(a) Hardware - The CRT shall be a nominal 12 inch diagonal suitable for either stand alone or console installation. The keyboard shall be desired for easy manual entry processors.

(b) Audio output - The OT shall include any necessary hardware required to drive a speaker or headset when monitoring the voice subsystem. The OT shall include an amplifier volume control.

15-2.2 OT design requirements

15-2.2.1 AWOS monitoring.- At the request of an operator, the OT shall display the information required by Part 12, paragraph 12-2.2.1.6.

When requesting archived data, it shall be possible to specify the time block in which data is requested, such as any specific observation or any block of observations during a specific time period. If the volume of data exceeds the capacity of the display screen, it shall be paged or scrolled under operator control.

15-2.2.2 Monitoring weather information in the broadcast

(1) The OT shall provide a display in the following format:

(a) Column 1: Current AWOS data (including station identification and time) (Part 12, paragraph 12-2.2.1.3.2.(a)).

(b) Column 2: Manually input weather information.

(2) The OT shall be the device that controls the AWOS broadcast. This shall be performed using the keyboard entry device, and the microphone for manual (analog) voice input. The following functions shall be provided through the OT:

(a) Augment any AWOS weather parameter, or replace inaccurate data with "MSG" (missing). When a parameter has been augmented by an observer, it shall not be announced "missing", but the observer's observation shall be entered as "comments". This procedure shall be performed as simply as possible, using only a minimum number of keystrokes to enter the revised parameter value and the appropriate prefix (such as "estimated"). (See paragraph 15-2.2.3). When a parameter has been augmented with manual data, the manual data shall be used in the AWOS broadcast.

(b) Change the AWOS Alpha identification.

(c) Manual input of additional weather information as comments.

(d) Identify the observation as an incident message, in accordance with the AWOS/ADAS ICD.

(e) Identify the observation as an urgent alert (i.e., tornado, funnel cloud, waterspout), in accordance with the AWOS/ADAS ICD. Highlight this observation on the OT and CVD displays for a period of 15 minutes.

(f) Highlight the OT and CVD displays of weather alerts generated automatically by the AWOS (Appendix 12-I, paragraph 1.2.9).

<u>15-2.2.3 Manual data entry</u>. - The entry of data shall be facilitated by special keys on the OT keyboard or menu driven. The more common remarks (i.e., Table A3-8A, Remarks Significant to Air Traffic Controllers, FMH-1) shall be initiated through use of a menu and shall be recognized by the computer generated voice unit. In order to insure against accidental activation of important keys such as the DELETE or ENTER keys, the procedure shall require two consecutive actions. For example, after pressing the DELETE key, the system could prompt with "DELETE: are you sure?" on the display requiring the operator to deliberately repeat his action.

15-2.2.4 Error Detection.- The AWOS processor shall check for incorrect entries by the operator, such as an altimeter setting which is out of the preset station pressure limits. Entry of apparently incorrect data shall result in an error message on the display followed by text or a code indicating the reason for rejecting the data. The OT shall contain an "override" procedure to permit entry of unusual, but accurate, information.

15-2.2.5 Security.- The OT shall be designed to prevent unauthorized persons from entering data into the system. The AWOS location will be identified as having or not having an OT; and if so, whether it is located in a secure or non-secure location. A site-specific configuration parameter will determine the station type for a given site. At secure locations, the following possibilities exist:

(1) Log in for a specified period of time. Modifications will be allowed for that period without requiring additional password verification.

(2) Log in separately every time a modification must be made.

(3) Once in the modification mode, toggle between AWOS and AWOS with Alpha character mode.

At the non-secure locations, the following possibilities exist:

(1) No operator terminal at the site (indicated by a site-specific parameter).

(2) Display-only operator terminal (indicated by a site-specific parameter). In this situation, any operator may view information, but no modifications are allowed. Any attempt to log in, which is a prerequisite to weather product modification, will be denied.

(3) Operator terminal for use by certified weather observer (indicated by a site-specific parameter). In this situation, an operator may do anything allowed at a towered installation, with the following exceptions:

   (a) An operator may not log in for a specified period of time. Only separate log-ins for each modification session will be allowed.

   (b) The toggle between AWOS mode and Alpha character mode will not be supported. Only AWOS mode will be allowed.

15-2.2.6 Periodic data validation.- All manually-entered data shall be automatically time tagged by the system. The data shall be valid until the next hourly observation. In order to retain the manually-entered data in the system, the operator shall be required to revalidate his entries at the hourly observation. The data shall be included in the hourly observation when input up to five minutes before the hour. If no data is to be changed, the operator shall be able to accomplish the revalidation using a simple procedure. The data shall then be tagged with a new one-hour limit. Manual inputs shall include a method of highlighting the "about to expire" entry two minutes prior to being deleted. This highlight shall be different than the manual entry highlight in the CVD described in Part 14, paragraph 14-2.3 (e.g., if reverse video is used to highlight a manual entry, blinking might be used to highlight an "about-to-expire" entry).

15-2.2.7 System initialization.- After a manual or an auto restart, the system constants stored in the DPU PROMS shall be loaded automatically into the system's working (RAM) memory. In addition, the OT shall provide the capability to reset the system clock.

15-2.2.8 AWOS status monitoring.- The OT shall provide a system operator the capability to monitor the system status. The capability shall meet the RMMS requirements specified in Part 19. The OT shall be designed to require the same type of commands and shall generate the same type of display as the RMMS. Using the OT, an operator shall be able to obtain the system data and perform the system diagnostics described in Part 12, paragraph 12-2.2.1.6.

15-2.3 Reliability and maintainability.- The reliability and maintainability requirements for the OT are as specified in Part 1.

15-3 Testing.- The contractor shall test the OT to demonstrate that the unit meets the stated performance requirements. As a minimum, the OT demonstration shall include (numbers in parentheses are paragraphs in Part 12):

(a) Monitor current output (12-2.2.1.6.1).

(b) Retrieve data (12-2.2.1.6.2).

(c) Edit AWOS products (12-2.2.1.6.3), to include rejection of erroneous inputs and simplicity of keyboard procedures.

(d) Modify the system, to include system initialization (12-2.2.1.6.4 and 15-2.2.7).

(e) Provide maintenance diagnostics data (12-2.2.1.6.5).

(f) Perform maintenance diagnostics (12-2.2.1.6.6).

(g) AWOS/OT communications security.

(h) Manual voice entry procedures and quality.

(i) Monitor weather information being broadcast.

PART 17 - SENSOR TEST AND CALIBRATION EQUIPMENT

17-1 PURPOSE

This part establishes the unique requirements for field (i.e., on-site) sensor test and calibration equipment. The general requirements for AWOS contained in Part 1 form a part of this specification.

17-2 REQUIREMENTS

17-2.1 General - The maintenance manual (Part 20, paragraph 20-2.3.2) will describe the procedures and adjustments required to calibrate and certify the AWOS. The previously stated requirements for Built-in-Test (BIT) and Remote Maintenance Monitoring (RMM) will provide the internal capability for calibration and certification of the AWOS. However, the procedures developed by the contractor (and included in the maintenance manual) may require additional equipment, external to the AWOS, to verify that the performance of AWOS sensors is within the required field tolerance during the periodic validation (recertification) of the the system. The contractor shall define the circumstances under which an external device (i.e., sensor test and calibration equipment) is necessary to verify sensor performance. The contractor shall provide the sensor test and calibration equipment to the Government as specified in the contract.

All test and calibration equipment shall be designed for operation by one technician and to operate in the environment of the equipment being tested. Portable Test and Calibration equipment designed for use outdoors shall be packaged into carrying cases whose individual weights do not exceed 40 lbs. The interior and exterior of each carrying case shall be designed to protect the contents against damage during repeated shipments. All test and calibration equipment shall be designed to operate on battery power or receive their power from the AWOS convenience outlets and be operated in a mode that does not interfere with the normal operation of the sensor. All test and calibration equipment shall be new and have a current calibration sticker.

PART 19 - SYSTEM INTERFACE REQUIREMENTS

19-1 PURPOSE

This part defines the AWOS interfaces, to include interfaces between the AWOS and the existing ATC system, as well as the modernized (future) ATC system.

19-2 REQUIREMENTS

19-2.1 General.- The FAA will provide to the contractor a copy of each Interface Control Document (ICD) in effect when the contract is signed (e.g., NAS-MD-790, for the RMMS). The contractor shall comply with these documents. It shall be the responsibility of the contractor to provide the necessary interface to those systems/subsystems not having a published ICD, and to provide an ICD for that interface in accordance with FAA-STD-025. The ICD shall be a subject for the Design Verification Reviews (Part 1, paragraph 1-4.3.1.3)

19-2.1.1 Interface ports and documentation.- The digital interface ports for the RMMS and ADAS shall be synchronous serial RS-232 ports, 2400 BPS with 2400 channel baud rate. The protocol standard will be a subset of ANSI X3.66 American National Standard for Advanced Data Communication Control Procedures (ADCCP), normal response mode with primary or secondary station in an unbalanced multidrop configuration, using a "Data Point Transfer Message" embedded in the data field. These standards are compatible with other FAA programs (e.g., NADIN, multiplexing modems, etc.). As used in this specification, RS-232 compatible means the contractor shall provide the capability to interface RS-232 devices with the local and off-site terminals in accordance with EIA-RS-232. Modems shall be provided when the distances exceed the interface design.

The AWOS shall contain the following interface ports. If an interface port does not already have an ICD (e.g. NAS-MD-790), interface documentation shall be developed by the contractor.

19-2.1.1.1 Sensors

(a) Input ports - none

(b) Output ports
DCP/DPU (1)

19-2.1.1.2 Data Collection Package (DCP)

(a) Input ports
Sensors (12)

(b) Output ports
DPU (1)

(c) Control input/data output ports
Maintenance Data Terminal (1)

19-2.1.1.3 Data Processing Unit (DPU)

(a) Input ports
Sensors (direct) (2)
DCP (2)

(b) Output ports (automatic dissemination)
Controller video display units (3)
Local voice subsystem to ground-air radio (1)
Local voice subsystem telephone answering device (5 lines)

(c) Control input/data output ports
Direct interface, AWOS RMS to RMMS (NAS-MD-790) (1)
OT (1): Voice and Digital
ADAS (1)
Maintenance data terminal (1)

19-2.1.1.4 Operator Terminal (OT)

(a) Input ports
Manual voice (microphone) input (1)
Keyboard (1)

(b) Output ports
Voice (1)
Speaker/headset (1)
Display (1)

(c) Control input/data output ports
DPU (digital) (1)

19-2.1.1.5 Video displays

(a) Input ports
DPU (1)

19-2.1.1.6 Maintenance data terminal

(a) Input ports
DCP/DPU (1)

19-2.2 AWOS-RMMS interface requirements.- The remote maintenance monitoring system (RMMS) is intended to fulfill the requirements of the FAA 80's maintenance program. The Enroute Maintenance Processor Subsystem (EMPS), the Sector Maintenance Processor Subsystem (SMPS) and the Remote Monitoring Subsystem Concentrator (RMSC) of the RMMS are centrally located data processors which control the RMMS communication links with all remote maintenance facilities. They also collect, record and analyze facility data. The RMMS components are procured separately under specification FAA-E-2698. The relationship between the various components of the RMMS are shown in Figure 19-1. The specific RMMS interface requirements are defined in NAS-MD-790. The operational requirements of the RMMS are described in NAS-MD-792, and the functional requirements of the Remote Monitoring Subsystem (RMS) are described in NAS-MD-793. ANSI x3.66 (ADCCP) shall be implemented as defined in NAS-MD-790 for synchronous data link communications. In addition, FED-STD-1003 requires a single octet in the address field to have the least significant bit set to (1).

The maintenance data terminal (MDT) ports shall be RS-232, asynchronous 2400 to 9600 bps (adjustable). In accordance with NAS-MD-793, the local mode protocol shall be compatible with the DEC-VT-100. The FAA will define the protocol for remote operation at a future date. Access by the MDT to the maintenance management system functions shall entail screen (block) data transfer.

19-2.2.1 General.- Each RMSC/EMPS/SMPS will collect maintenance data from up to 25 AWOS sites. AWOS-generated failure messages are collected and displayed by the RMMS to alert maintenance personnel to the need for AWOS repair. Failure statistics are also collected by the unit in order to highlight frequent intermittent failures that indicate potential hard failures and the need for unit recalibration or maintenance.

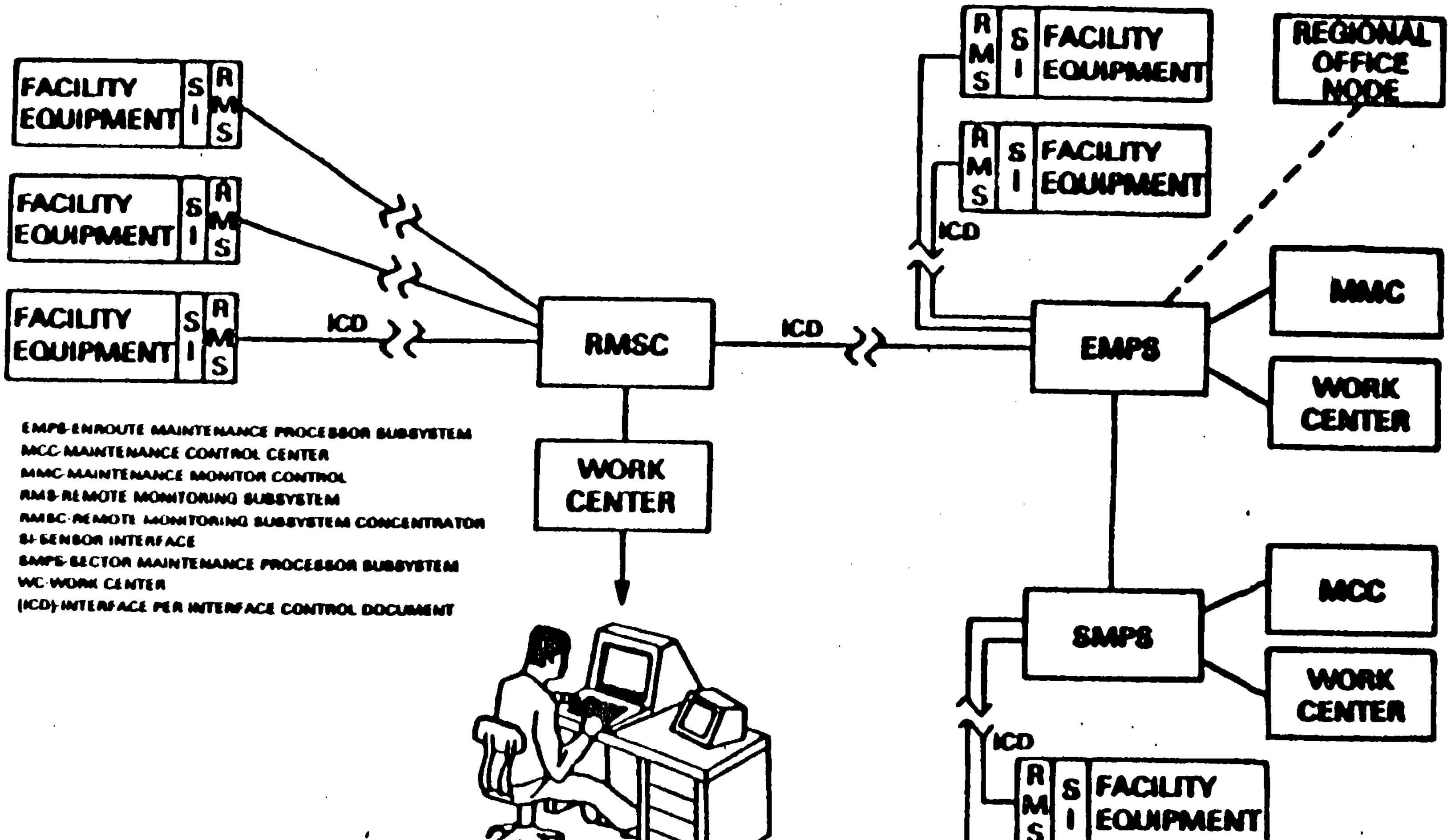
The RMSC/EMPS/SMPS enables remotely-located personnel to interrogate any AWOS within their area of responsibility to obtain current reports, to measure all system parameters required for system recertification and to obtain the status of the various AWOS subsystems. The unit also allows maintenance personnel to examine raw sensor data, as well as sensor and subsystem RMM parameters in order to determine where a failure occurred and identify required repairs to the line replaceable unit.

19-2.2.2 Performance.- The RMSC/EMPS/SMPS performs the following functions:

(a) Automatically polls all AWOS systems within its area of responsibility to obtain system status data. The AWOS report is made available for display at the RMMS station, is recorded on digital tape, and, if required, a hard copy is provided by a printer.

MAINTENANCE PROCESSORS PROGRAM

REMOTE MAINTENANCE MONITORING SYSTEM (RMMS)



TYPICAL ARRANGEMENT OF CENTRAL AND REMOTE ELEMENTS OF RMMS

Figure 19-1

(b) During the automatic poll, the RMSC/EMPS/SMPS collects all AWOS error and failure data (both intermittent and hard failures) detected by the various AWOS quality control checks.

RMSP/EMPS/SMPS maintains statistics (frequency and type) of all errors and failures for each AWOS installation. Occurrence of a hard failure at an AWOS site results in a special message being generated by the RMMS in highlighted form on the display and a special message on the printer. The AWOS failure data is archived by the system for retrieval by maintenance personnel.

(c) The RMSC/EMPS/SMPS also enables an operator to interrogate the status of any AWOS to determine the condition of the system. The operator can request (via keyboard commands) the display and print-out of any AWOS data necessary to determine whether adjustment or calibration is required, or those data required for periodic system recertification. Some examples of these data include raw sensor data from any sensor or group of sensors, sensor RMM signals, power supply outputs, equipment temperatures, input power levels, and the condition of the voice unit and microprocessors.

(d) The RMMS allows an operator to request the current AWOS product output and the archived data. This data can be displayed on the RMM video display, and hard copy provided by a printer.

(e) In case of a failure, the RMMS enables an operator to perform diagnostics on the system in order to identify the source of the failure to the line replaceable unit.

(f) The RMMS provides the operator with the capability to reconfigure the AWOS from the remote site. For example, if the data consistency checks reveal a sensor failure, the AWOS can be commanded to discontinue use of this sensor.

It is the responsibility of the contractor to implement in the AWOS all hardware and software functions required to achieve the specified RMM capabilities, and to provide the AWOS RMM output at the AWOS-RMMS and the ADAS output interface ports.

<u>19-2.2.3 AWOS-RMMS communication link</u>.- The AWOS-RMMS interface will be via the Remote Monitoring Subsystem (RMS) in accordance with NAS-MD-793. ANSI x3.66 (ADCCP) shall be implemented as defined in NAS-MD-790 for synchronous data link communications. In addition, FED-STD-1003 requires a single octet in the address field to have the least significant bit set to (1).

<u>19-2.2.4 AWOS-RMMS messages</u>.- Messages that are exchanged between the RMSC/EMPS/SMPS and the AWOS include AWOS failure, AWOS product and AWOS status messages.

19-2.2.4.1 Failure messages.- AWOS failure messages have the highest priority for transmission, and shall be treated as time critical messages. Failure messages shall be ready for transmission within 1 minute after detection of the failure condition at the AWOS station, and be sent at the earliest possible time. If any priority messages are pending when polled, the AWOS shall respond by sending the priority messages when polled. Failure messages shall provide an identification of the AWOS station reporting the failure. These messages shall also indicate the monitored parameters that caused the failure declaration, and the measured value. The specific text format of the failure message shall be defined and provided by the contractor during the Design Verification Reviews (Part 1, paragraph 1-4.3.1.3).

19-2.2.4.2 AWOS status messages.- AWOS status messages shall be transmitted by the AWOS in response to a status request for any specific AWOS. Status messages shall be sent immediately in response to the RMMS poll. After failure messages, AWOS status messages have the highest priority.

19-2.2.4.3 AWOS product messages.- Responses to AWOS Product Requests shall be transmitted by the AWOS immediately in response to the RMMS poll.

19-2.3 AWOS-ADAS Interface Requirement. - The AWOS-ADAS interface port is the means for off-airport distribution of operational weather data. It also provides the means for the AWOS DPU to receive cloud-to-ground lightning flash data from the ADAS. The routine digital output message from the AWOS to the ADAS will contain the current weather observation. The requirements for and the implementation criteria of the logical interface between the AWOS and the ADAS are defined in the AWOS/ADAS ICD 10-001 (Draft).

19-3 Testing.- The contractor shall demonstrate compliance with the AWOS interface requirements by demonstrating the proper operation of the interfaces.

PART 20 DOCUMENTATION

20-1 PURPOSE

This Part itemizes and amplifies the documentation requirements of this specification. Every document required by this specification is not listed in this Part.

20-2 REQUIREMENTS

20-2.1 General.- The contractor shall be responsible for providing the documentation necessary to describe the design and construction, testing, installation, operation, maintenance, operational and maintenance training, and supply support for the entire AWOS system and each subsystem described in other parts of this specification.

20-2.2 Submission.

(a) Manuals - The number of manuscript copies of each manual to be provided shall be specified in the contract. These documents shall be prepared in accordance with the requirements established in FAA-D-2494. One reproducible (camera ready) copy of each document shall be provided. Commercial manuals for off-the-shelf equipment may be acceptable (subject to government approval) provided they meet the requirements specified in MIL-M-7298.

(b) Plans- Plans shall be submitted in accordance with instructions in Part 1 of this specification.

(c) Drawings - All drawings shall be made on clear-print paper No. 1000H or equal with the FAA title block in the lower right hand corner. Drawings will be prepared in accordance with FAA-STD-002 and DOD-STD-100 and submitted for approval as specified in the contract. Since these drawings will be further reduced in size by the FAA in the future, the drawings shall be clear and legible. The details and printing shall be of the size required for microfilming on 35 mm film. The minimum letter height for a 22" x 34" sheet will be 5/32" and .05" spacing between letters. All letters shall be vertical capital letters.

20-2.3 Documentation required.

20-2.3.1 Operations manuals.- The operating instructions shall contain a complete, step-by-step description of all operating procedures. A separate manual shall be prepared with instructions for the Operator Terminal (OT). These procedures shall be in sufficient detail to provide an operator (who has no formal AWOS training) with the expertise necessary to perform each operational function. (An operator is defined as an ATCT operator, TRACON operator, weather observer, or similar person).

20-2.3.2 Maintenance manuals.- The maintenance instructions shall contain a complete description of:

(a) All maintenance procedures and adjustments performed periodically to calibrate and prevent failure of any part of the system (periodic maintenance). The procedures shall include the time allocated to each operation during each scheduled maintenance visit.

(b) All maintenance procedures and actions performed by a maintenance technician to diagnose (locate) any fault in any part of the system (with specific instructions on the use of test equipment), and then to repair, adjust and calibrate the equipment to meet the standards in this specification.

Maintenance instructions shall include a description of the operation of the mechanical and electrical/electronic systems of the AWOS in sufficient detail to permit an FAA or contractor maintenance technician with no formal AWOS training to accomplish all on-equipment on-site and sector work center (off-equipment off-site) or depot-level maintenance actions. A separate manual (or separate section of a manual) shall be provided for each subsystem (e.g., for each sensor, the DCP, the DPU, the displays, etc.).

20-2.3.3 Installation/checkout manual.- The contractor shall provide step-by-step instructions for the installation and checkout of the AWOS. The instructions shall include assembly, mounting and connection procedures, servicing procedures, and bonding and grounding procedures if applicable. Step-by-step procedures shall be provided to demonstrate that the system is operating correctly and within specified tolerances. This manual shall include the information necessary for FAA engineering or contractor personnel to properly engineer the installation of a system. This information shall include, but not be limited to:

(a) Dimensions of equipment cabinets, mounting brackets, sensors, etc.

(b) Inside and outside pictures of all cabinets to assist in the location of conduit and cable entry into cabinet.

(c) Sensor mounting details.

<u>20-2.3.4 Software/firmware documentation manuals</u>.- Software/firmware that is developed for AWOS shall be done in accordance with the process and documentation as specified in the contract. Complete documentation of all microprocessor/microcomputer programs and software/firmware programs shall be provided and delivered in accordance with the contract schedule. Flow charts, functional specifications, performance specification and program listings shall be cross-referenced so as to provide ease of determination of where and how all specific and general requirements are met. Documentation shall normally include the following information:

(a) <u>Configuration Index Document (CID) (Document No. 1)</u>. The CID is a major control document for a unique software version and serves as an index of all applicable documentation. It shall provide a historical reference to all documents under configuration control and indicates the current status of each document. It shall contain hardware names and part number for all LRUs comprising the system and software part numbers for all LRUs employing software.

(b) <u>Software Requirements Document (Document No. 2)</u>. This document shall contain (but is not necessarily limited to) the functional and operational requirements of the software stated in quantitative terms with tolerances where applicable; general and descriptive material including a functional block diagram or equivalent representation of each computer program; graphic illustration of functional operation and the relationship between functions.

(c) <u>Design Description Document (Document No. 3)</u>. This document shall describe the design of the software program and the traceability of requirements from Document No. 2 to the design and implementation.

(d) <u>Programmer's Manual (Document No. 4)</u>. This document shall provide adequate information for understanding and programming each microcomputer/microprocessor used in the equipment. This information shall include a complete architecture description (instruction set operation) and programming language description manual.

(e) <u>Software Configuration Management (Document No. 5)</u>. This document shall be designed so as to provide assurance that the end product will function as specified. It shall describe the configuration control and related procedures to be used.

(f) Source Listing (Document No. 6). This document shall contain source statements for the computer program and the annotations to describe modules, functions and program flow. The listing shall include the program part number, the program name and the date of release.

(g) Source Code (Document No. 7). Source code shall use paper and magnetic discs, with an agreed upon size and format, and shall be a deliverable to the Government as specified in the contract.

(h) Object Code (Document No. 8). Object code shall use paper and magnetic discs, with an agreed upon size and format, and shall be a deliverable to the Government as specified in the contract.

(i) Support/Development System Configuration (Document No. 9). This document shall describe the hardware, software and processes used to develop and maintain the software and to produce the source and object code.

(j) Accomplishment Summary (Document No. 10). This document shall be a brief description (one to four pages) of the tasks accomplished during development of the software and of the plan for configuration management. Items addressed in the summary include system description, design disciplines, testing and monitoring.

(k) Software Test Plans/Procedures and Results (Document(s) No. 11). These documents shall be tailored to the various software/firmware test phases. They shall describe tests to be performed, the purpose of each test, functions to be tested and sequences and methods of testing. They shall also cover means of verification/validation, test equipment requirements, test software requirements and results.

(l) Software Design Standards (Document No. 12). This document shall specify the software design and implementation standards defined as applicable to the software development and test process. It shall also describe and prohibit types of software implementations which might jeopardize meeting the functional objectives of the systems.

(m) System Requirements (Document No. 13). The System Requirements Document shall describe the overall system to be certified. It shall contain the following:

(1) A system description containing functional block diagrams, LRU component breakdowns and descriptions of functions to be certificated;

(2) Certification requirements, including all applicable FARs, Advisory Circulars, FAA requirements and other; and

(3) Means of compliance.

20-2.3.5 Sensor Test and Calibration Equipment instruction manual.- These instructions document the operation, and describe the fault isolation and diagnostic functions of the TCU.

20-2.3.6 Interface control documents (manuals).- See Part 19, paragraph 19-2.1.

20-2.3.7 Quality Control System Plan.- See paragraph 1-4 of this specification.

20-2.3.8 Reliability program plan.- See paragraphs 1-3.5 and 1-4 of this specification.

20-2.3.9 Maintainability program plan.- See paragraphs 1-3.5 and 1-4 of this specification.

20-2.3.10 Test plan.- See paragraph 1-4 of this specification.

20-2.3.11 Parts List.- The contractor shall provide a tabulation of descriptive data on all electrical, electronic, mechanical and electromechanical assemblies and subassemblies to the component level. The descriptive data shall provide a generic identification, adequate for procurement purposes, of each item. It shall contain the original manufacturer's identification number cross referenced to the AWOS contractor's identification number. This data shall be titled "PARTS LIST."

20-2.3.12 Engineering schematic drawings.- The contractor shall provide to the Government a complete set of engineering drawings of every subsystem of the AWOS system. Each component shall be cross referenced to its identification number in the Parts List.

PART 21 MICROCOMPUTER DEVELOPMENT SYSTEM

21-1 PURPOSE

This Part establishes the performance and test requirements for a Microcomputer Development System (MDS) for AWOS. The general requirements for AWOS contained in Part 1 form a part of this specification.

21-2 REQUIREMENTS

21-2.1 General.- The MDS shall be a commercially available unit. It shall be the same system used by the contractor to develop the AWOS software/firmware. Consideration should be given to using the HP 64000 to maintain compatibility with other FAA systems. The MDS shall include all options necessary for the development of software, emulation of software and hardware debugging, and real time microcomputer analysis. The system shall also include a production PROM programmer to support future software changes which require programming and distribution of new sets of PROMS to each AWOS site.

21-2.2 MDS Specification.- The MDS shall be a complete, commercially available microprocessor development system consisting of a controller, display, keyboard, disk drives, PROM programmer, PROM eraser, printer, emulator, software, production PROM programmer and all related material, such as manuals, prints, equipment stand, etc. One system shall be delivered with all components necessary to support the microprocessor used in the AWOS design, such as the specific emulator, PROM personality cards, and software support package. The MDS shall meet the following minimum requirements:

(a) The MDS shall be a commercially available system. It shall not include any unique designs, modules or units not available from the manufacturer as a standard product.

(b) The delivered MDS shall include the programming language (C language, paragraph 12-2.2.3.2) used in the AWOS software design.

(c) The delivered MDS shall include all hardware and software options associated in the microprocessor used in the AWOS design. These shall include, but not be limited to, the high level programming language, assembler, editor, linker, emulator, and any MDS/microcomputer interface hardware necessary to debug any AWOS processor board.

(d) The MDS shall be purchased from a manufacturer with a national service organization and technicians who shall be capable of providing repair/maintenance service for the MDS within 24 hours after receiving the service request.

(e) The MDS shall operate from nominal 120V, 60Hz power in ambient temperatures of 40° F to 95° F, 90% RH, noncondensing.

21-3 Testing.- The contractor shall demonstrate that all MDS features are operating satisfactorily by assembling the entire MDS and interfacing it with the AWOS processor. The test shall include demonstration of the operation of the following MDS features:

(a) Generation of software in the selected C language. Program entry and editing.

(b) Program assembly.

(c) System emulation including program execution from MDS memory, and transfer to the AWOS processor memory. Verify operation in trace mode, breakpoints, and program correction using the editor.

PART 22 - DATA LINKS

22-1 PURPOSE.- This Part establishes the requirements for the AWOS data links provided by the contractor. The general requirements for AWOS contained in Part 1 form a part of this specification.

22-2 REQUIREMENTS

22-2.1 General.- Data links shall be provided between the DCP(s) and DPU and between the DPU and the displays (Part 14) and operator terminal(s) (Part 15). These data links shall be provided by the contractor, except, on a site-specific basis and as specified by the contract, links (or segments) shall be provided by the Government over existing communications systems. The AWOS subsystems shall be designed to accommodate wire, fiber optics and radio communications data links. The specific mode, or combination of modes, to be used at each AWOS individual installation shall be as specified by the contract, and the necessary interface(s) shall be incorporated in the equipment before shipment of the AWOS from the factory.

22-2.2 Characteristics

22-2.2.1 Wire.- Wire lines may be either voice channel lines (for distances greater than 20 miles) or metallic voice pairs (for distances less than 20 miles). Voice channels shall be equivalent to unconditioned ATT tariff class 3002 standards (contained in Bell Publication 43401). Metallic wire pairs shall also be equivalent to those described in that publication. The transmitting and receiving devices shall also meet the requirements of Bell Publication 43401. Wire lines shall be dedicated, No. 19 AWG copper pairs, 10 mil copper shielded/armored, moisture protecting filled, direct burial, polyethylene insulated and jacketed telephone cable.

22-2.2.2 Fiber optics.- The contractor shall select cable to meet the requirement for the particular installation. The specifications for this cable shall be included in the CSER along with an analysis to show that the cable meets the requirement and was tested in accordance with test methods in DOD-STD-1678 (or equivalent). The life expectancy of the cable shall be at least 20 years for both conduit and direct burial. The optical cable shall contain at least 50 percent spares. At least 40 percent of the spares shall be interfaced to their own light source and detector. The fiber optics modems shall be considered an integral part of the fiber optics link and shall be designed to the environmental conditions specified in Part 1, paragraph 1-3.2.2.2.

22-2.2.3 Radio link.- The maximum transmission distance of the radio link is approximately 10,000 feet. The radio link shall be designed to accommodate a 600 ohm balanced or 50 ohm unbalanced termination at a signal level of 0 dbm. In the event that the distances between transmitter/receiver and the equipment interfaces are such that communications lines are required, the lines specified in paragraphs 22-2.1 and 22-2.2 shall be used. Transmission frequencies shall be in the 162-174 mHz, 406-420 mHz, or 1700-1850 mHz bands, on a site specific basis as specified in the contract. The equipment shall meet the specifications outlined in the NTIA (National Telecommunications and Information Administration) Manual of Regulations and Procedures for Federal Radio Frequency Management, and must have FCC type acceptance in accordance with the procedures set forth in the FCC Rules and Regulations, Part 2.

22-2.2.4 Data rates.- The data links shall be designed and configured to transmit/receive data at rates up to and including 2400 baud with a bit error rate not to exceed 10^{-6}.

22-3 Testing.- The contractor shall include the necessary tests in the Test Plan (Part 1, paragraph 1-4.2) to demonstrate (during Specification Compliance Testing, (paragraph 1-4.3.2.1)) that the radio, fiber optics and wire data link comply with the requirements of this specification. (These tests may be performed while the preproduction systems are installed and operated under field conditions). In addition, each data link in every AWOS installation shall be an integral part of preliminary testing, the Joint Acceptance Inspection and the 120 hour stabilization run as specified in the contract. Performance deficiencies attributable to Government-furnished links, as jointly determined by the contractor and FAA Technical Representative (TR), shall be resolved by the FAA TR.

PART 23 - PHYSICAL SUPPORT SUBSYSTEM

23-1 PURPOSE

This Part establishes the requirements for hardware and other items required for the AWOS installation. The general requirements for AWOS contained in Part 1 form a part of this specification.

23-2 REQUIREMENTS

23-2.1 General.- As used herein, the term "hardware" consists of all items necessary to install the AWOS equipment. It includes, but is not limited to, platforms, pads, towers, brackets, mounts, pedestals, junction boxes, booms, shelters, etc. All steel parts (including bolts, nuts and washers) shall be hot dip galvanized after fabrication. Finishes shall be in accordance with Part 1, paragraph 1-3.7. Lightning and EMI protection shall be in accordance with Part 1, paragraphs 1-3.3.3.5 and 1-3.3.3.6. The hardware shall be designed to survive winds of 100 knots. The design shall conform to the safety standards specified in applicable portions of Department of Labor Standard, Title 29, Chapter XVII, Part 1910. Generic hardware specifications, design analyses, design and erection drawings shall be developed by the contractor for the basic AWOS system. Site specific requirements (i.e., foundation requirements) shall be addressed in the Contractor's Site Engineering Report (CSER) as required in the contract.

23-2.2 Use of existing towers.- Use of existing towers (e.g., glide slope antenna tower) shall be as specified in the approved CSER. At these locations, the contractor shall be responsible for providing the hardware required to mount the wind speed and direction sensors. If side mounting (i.e., perpendicular to the tower) is necessary, a boom shall be provided to permit installation of the sensors a minimum of one meter laterally from the tower. The boom shall be retractable or fold-in to allow access to the sensors from the tower for maintenance. However, whether in an extended or retracted or folded position, no portion of the boom or sensors shall extend beyond the front face of the glide slope antenna.

23-2.3 New wind sensor support structures.- New support structures (i.e., towers) shall be designed for top mounting of wind sensors. The height of the sensors shall be in accordance with the AWOS siting criteria and as specified in the approved CSER. A double L-810 obstruction light shall be mounted within five feet of the top of the tower. The obstruction light shall consist of two L-810 fixtures selected from the approved equipment listed in FAA-AC 150/5345-1 with the lamps wired in parallel. Lightning protection shall be provided in accordance with Part 1, paragraph 1-3.3.3.5. The support structures shall be designed to provide compliance with the MTTR requirements in Part 1, paragraph 1-3.5.2 and Part 2, paragraph 2-2.1 when maintenance is performed on the wind sensors. Therefore, consideration should be given to a structure that can be folded-up/down or cranked-up/down so that maintenance can be performed at ground level. Towers shall be mounted on a concrete foundation. Concrete shall be as specified in paragraph 23-2.5.

23-2.4 Platforms.- A platform shall be used where it is necessary to elevate the cloud height, visibility, precipitation and temperature/dew point sensors above ground level because of snow accumulation. The platforms shall be sized by the contractor to provide ready access to all equipment for maintenance. A stairway shall be provided. The platform height at each location shall be in accordance with the AWOS siting criteria and the approved CSER. Platforms shall be mounted on a concrete foundation. Concrete shall be as specified in paragraph 23-2.5.

23-2.5 Pads.- Concrete pads (for sensor support) shall be used at locations where it is not necessary to elevate sensor mounts or pedestals above ground level. Pads shall not normally extend more than 18 inches above ground level. The pads shall be sized by the contractor to provide ready access to all equipment for maintenance. Concrete pads shall be a minimum 3000 pounds per square inch concrete of portland cement, fine and coarse aggregate and air entrainment agent in accordance with Standard ACI-318 American Concrete Institute Standard Building Code Requirements for Reinforced Concrete. The concrete shall have a maximum slump of 3 inches. Concrete reinforcement shall be deformed reinforcement steel conforming to ASTM A615 Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement or equal. Construction of all concrete work shall conform to Part 3 "Construction Requirements" of ACI-318. The bottom of all foundations shall be carried a minimum depth of 12 inches below the local frost depth unless other approved methods are used to prevent frost heave of the foundations, such as pile foundations. Excavation deeper than the required depth shall be brought to the correct level with plain concrete, which shall be allowed to harden before the concrete pad is placed. All foundation designs shall be site adapted by the contractor as necessary to meet local soil conditions and the reactions resulting from the maximum dead and live loads the platform pads, etc. must sustain. The top four edges of the foundation piers, pedestals, etc., shall be chamfered a minimum of one inch for the entire width of each face.

23-2.6 Junction boxes.- Power and communications junction boxes installed outdoors shall be weatherproof enclosures. Enclosures shall be designed and constructed in accordance with best commercial practices and shall meet the requirements of Part 1, paragraph 1-3.3.3.17.

23-2.7 Cabling.- The contractor shall furnish all power and communications cable, except, on a site-specific basis and as specified cable (or segments) shall be provided by the Government using existing facilities. However, at all sites the contractor shall be responsible for all cabling between the sensors and the DCP and between the DPU and the peripherals.

23-2.7.1 Power cable.- All power cables shall conform to the National Electrical Code (NFPA No. 70) and local, state and city requirements. All underground cable shall be armor-sheath cable.

23-2.7.2 Communications cable

23-2.7.2.1 Wire.- Wire cable shall be dedicated, No. 19 AWG copper pairs, 10 mil copper shielded/armored, moisture protection filled, direct burial, polyethylene insulated and jacketed telephone cable.

23-2.7.2.2 Fiber optic.- The contractor shall select cable that has been tested in accordance with DOD-STD-1678 (or equivalent) to meet the requirement for tensile and bending strength and optical attenuation applicable to the specific site. Attenuation of the cable shall be measured end-to-end after splicing. Life expectancy shall be at least 20 years for both conduit and direct burial cable.